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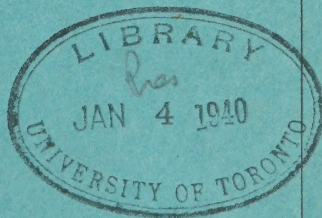
PUBLIC WORKS IN CANADA

*Under the Department
of Public Works*

By

K. M. CAMERON, M.Sc., M.E.I.C.

Chief Engineer



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Public Works in Canada Under The Department of Public Works

When Jacques Cartier, in 1534, on his voyage of adventure to pioneer the route to the wealth of Cathay and the Spice Islands reached and sailed up the River St. Lawrence he was but the first of the intrepid adventurers who, while relegating the search for the Western Passage to a place second to that of trade in Canada never lost faith in its ultimate discovery.

Pursuing their various ways westward, these pioneers combined exploration with trade and followed the waterways so generously provided by nature, but beset by natural obstacles to travel therein which taxed their meagre means to surmount. While Martin Frobisher reached the American continent at Baffin Island in 1576, he preceded Hudson who discovered in 1610 the Bay that bears his name. The Merchant Adventurers from England were operating by the Northern Route, but their French competitors were stretching their long trade routes up the St. Lawrence and Ottawa Rivers, penetrating the continent to Lake Winnipeg, the Saskatchewan River, and down the Mississippi.

By the Northern or Hudson Bay route Hearn reached Coronation Gulf and Great Slave Lake in 1771-72, Mackenzie the Beaufort sea by the river which bears his name in 1789, Sir John Franklin went overland and by the lakes and rivers to Coronation Gulf and the Mackenzie in 1819 and 1825; on his latter desperate attempt, by sea, in 1845, he perished with all his men. Amundsen between 1903 and 1906 sailing west from Baffin Bay to Behring Strait was the first man to make the northwest Passage.

The St. Lawrence or Southern route, pre-empted by the French, was not less productive of sustained heroic enterprise. Champlain, who had been with DeMonts in the exploration of the Bay of Fundy and the coast of Nova Scotia, and the efforts then made to plant colonies in New France in 1604 and 1607 then turned his efforts and abilities to the St. Lawrence Valley, ascending the Ottawa part way in 1613, and again in 1615, proceeding through to Georgian Bay and returning by the Trent Valley. Dollier de Casson's party in 1669-70 discovered Lake Erie, Marquette reached and followed the Mississippi to the Arkansas in 1673, and LaSalle in 1682 followed that great river through to the Gulf of Mexico.

While the explorers were following the northern and overland routes, we find the seafarers, Bering voyaging to the Alaskan Coast in 1741, and Cook extending the discoveries of the Pacific Coast from the mouth of the Columbia to the Gulf of Alaska in 1778, Vancouver following him, but in

more detailed fashion, in 1792-94. Vancouver, and Mackenzie the discoverer of the Mackenzie River, nearly met as the latter made the first overland crossing of Canada to the Pacific in 1793 when Vancouver was busily exploring the coast of what is now British Columbia. Fraser in 1808, and Thompson in 1807-11 were more fortunate in their discoveries of overland routes to the Pacific, and their names are, like Mackenzie's perpetuated in the rivers which bear their names.

To the fur trade with its admirably organized systems of transportation by canoe and York boats on the Inland Waterways and by sailing boats on the oceans is properly given the credit of our first knowledge of that vast geological area known as the Precambrian Shield, with its unique network of rivers and lakes and its wealth of furs, timber and minerals, and which comprises two-thirds of the area of Canada. It is to the gradual assembly of knowledge of the resources of this vast area, synchronizing with the demand of the increasing population of the Old World for new areas in which to have freedom to expand and with the demand for, first, timber and, later, foodstuffs, principally wheat, that has brought about the present formation and development of Canada, and as population and development of Canada proceed the public need for increased facilities for inter- and intra-country commerce must keep pace.

Early History

Under the Union in 1841 of the provinces of Upper and Lower Canada the Public Works were carried on by Commissioners of Public Works who had charge of the canals, the works in navigable waters, the harbours, the lighthouses, beacons and buoys, the slides and booms, the roads and bridges, the public buildings and the provincial vessels. Prior to the Confederation of the provinces of Ontario, Quebec, New Brunswick and Nova Scotia in 1867, this body had disbursed on these public works the sum of \$20,927,560.86, of which \$10,163,088.60 had been the cost of the canals. It is interesting to note that apparently no traffic existed on Lake Superior of sufficient amount to warrant any expenditure for any purpose thereon by the United Provinces, although a canal had been constructed past the rapids, at Sault Ste. Marie, on the United States side, by a private company. This was much later than the lock on the Canadian side, built about 1803 by the North West Company. The most westerly place at which expenditure on harbour development had been incurred was at Meaford, on Lake Huron, although it is recorded that expenditures had been made for harbours and piers, as also for lighthouses, on Lake Huron. Again, the Ottawa River had benefited to the extent of \$3,642.54 expended on lighthouses in that 26-year period.

The public buildings of the United Provinces numbered 71, including 29 Court Houses, Schools and Gaols; Post Offices numbered 6, and Customs Houses 10. Scientific Institutions were however not neglected, as Observatories were maintained at Quebec and at Toronto.

The River St. Lawrence was usable for the largest vessels then afloat up to Quebec, but beyond that the draft of vessels was limited to 10 to 12 feet by lack of greater depth through Lake St. Peter. Immediately after the union of Upper and Lower Canada, D. Thompson, Civil Engineer, was commissioned to examine the channel and, following his report favouring a 16-foot channel the sum of £60,000 sterling was voted, and work was commenced in 1844. The work was suspended when funds became exhausted in 1847 and was resumed under the Harbour Commissioners of Montreal, the project depth being increased to 20 feet in 1855, the channel width being 300 feet. This project of a 20-foot channel was completed in 1865.

The Confederation in 1867 of the provinces of Ontario, Quebec, New Brunswick and Nova Scotia was augmented by the province of Manitoba in 1870, by the Northwest Territories in 1870, by British Columbia in 1871 and by Prince Edward Island in 1873.

Slides and Booms

That the resources of the provinces in timber were of great commercial importance in the early days as well as up to the present is indicated by the comparatively large expenditures made from the meagre funds then available in constructing slides and booms to aid the passage of timber at sections in the main waterways where major obstructions existed.

The Saguenay River slides and booms were commenced in 1856, and at Confederation had cost \$44,872.79. At that date the net revenue was \$1,878.20. The St. Maurice River works were built from 1852 to 1866, and extended to Plamondon's Eddy, 106 miles above Three Rivers. The expenditure had been \$269,043.03, and a deficit of \$75,378.40 had resulted.

On the Ottawa River the first works to aid the movement of timber were carried out by private individuals, Philemon Wright building a slide at the Chaudiere Falls in what is now Hull, in 1829. The United Provinces purchased the private-owned works on the river, and up to Confederation had expended \$762,769.69 on acquisition and improvements, and had secured therefrom a net revenue of \$488,403.38. These works served the trade over the very considerable distance of 249 miles of the river above Ste. Anne de Bellevue. The works acquired and constructed served in addition the Gatineau, Madawaska and other major tributaries.¹

Roads and Bridges

Prior to the Union in 1841, and from the Union to Confederation in 1867, the provinces had necessarily supplemented the original and still the main transportation routes, which were by the waterways, with roads to serve the needs of the colonists for more rapid means of travel and communication.

(1) Part 6, Annual Report Public Works, 1909-10.

The main provincial highway, from Gaspé Basin on the south side of the St. Lawrence, and from Portneuf, 181 miles below Quebec on the north side of the St. Lawrence, Canada East, extended to Sandwich on the Detroit River and to Sarnia, at the foot of Lake Huron, in Canada West. Together with main branch roads and other tributaries the length totalled 2,118·68 miles, for much the greater part "common or gravel," but in stretches macadamized as were the portions at Caughnawaga for 6-16/100 miles, and Yonge Street from Toronto to Holland's Landing, or planked as from Cascades to Coteau du Lac, 14½ miles, or Whitby (then Windsor) harbour to Lake Scugog, 6¾ miles. Main branch roads ran from Quebec to the Maine border, known as the Kennebec road, the Gosford road from Quebec to Sherbrooke, Kingston to Ottawa, Toronto to Penetanguishene, L'Orignal to Pembroke via Ottawa, and Montreal to Sherbrooke and Stanstead. The expenditure before and during the Union, to Confederation was \$3,312,593.70.

The Confederation pact gave the roads, except military roads, and bridges to the Provinces, and Dominion Government expenditures thereon since then have been as subsidy for road purposes paid to the Provinces.

Light Houses, Beacons and Buoys

The dependence of the provinces on water transportation for development of the efforts to colonize their vast areas and extend their trade in the natural resources had required the establishment of lighthouses, and other aids to navigation to keep pace with the requirements of shipping. Throughout the whole course of Canadian inland navigation they had erected 131 lighthouses, from the stone tower light at the Strait of Belle Isle, the most easterly, erected in 1858, at a cost of \$86,830, to the wooden tower light at St. Ignace Island in Lake Superior, under construction in 1867. Four lightships are included in the number, all in Lake St. Louis, on the St. Lawrence route. The Trinity Board of Quebec were given management of lights below Quebec, having constructed several in addition to those built by the Government, the earliest apparently being the light at Green Island, first operated in 1809. From Quebec to Montreal the aids were managed by the Trinity Board of Montreal, which body had constructed a number of aids in addition to those erected by the Government. A light was first established at Lotbiniere in 1816, and a light vessel placed in Lake St. Peter the same year.

The functions of the Government under Confederation were rearranged from those existing prior thereto, and thus lighthouses, beacons, buoys and aids to navigation then became the responsibility of the new Department of Marine. They are therefore not dealt with further in this paper.

Provincial Vessels

That vessels propelled by sails were still in the ascendancy in those early days and had not been replaced by steam, particularly for Ocean traffic is apparent from the complaints made on behalf of the shipping

interests that owing to the absence of Government tug boats on the St. Lawrence, below Quebec, vessels were often delayed for many days by contrary winds both in the River and the Gulf, that these delays were in many ways injurious to the commerce of the country, that the want of tug boats was one of the principal causes why Marine Insurance on vessels visiting Canada was maintained at such high rates, and why the rates of Ocean freight charged by vessels ran so high.

From 1853 to 1859 the performance of such a service was placed in the hands of a contractor, but having proven unsatisfactory the Government took over this service and continued it under the Department of Public Works. To enable the Crown Lands Department to carry on a Fisheries Protection Service, organized in 1852, the Department of Public Works provided and maintained the necessary vessels. In the discharge of the above duties, and those of supplying the lighthouses and depots of provisions for distressed mariners, laying down and servicing buoys, and surveying the channels with the apprentice pilots and officers of Quebec Trinity House, carrying passengers, mails and freight between Quebec and the Lower ports, and rendering aid to distressed vessels, the Government had in commission the ss. *Lady Head*, the *Napoleon III*, both screw propelled and built in Scotland, of iron; the wooden paddle wheel steamer *Advance*, built at Quebec; the schooner rigged and screw propelled *Queen Victoria*, built of iron, in Scotland, and the wooden sailing schooner *La Canadienne*.

As these duties were assumed at Confederation by the Marine Department, they are therefore not dealt with further herein.

The *Royal William* was the first steamer to cross the Atlantic, from Quebec, that passage being made in 1841. Indicating the changes and growth of shipping on the St. Lawrence we see that in 1764 there were 67 vessels of 5,496 tonnage, with crews totalling 568 men arriving in Quebec; by the end of that century the number of vessels had increased to 141, of 16,767 tonnage and crews of 1,798 men; and when the first steamer sailed in 1841 there were 1,026 sailing vessels cleared of 263,160 tonnage and crews of 13,329 men. The lone *Royal William* was of 363 tonnage, with a crew of 21 men. The first regular steam ocean liners, together with government tug boats and other steamers in Quebec in 1856 numbered 18, of 16,599 tonnage; at Confederation there were 73 steamers of 75,611 tonnage. Sailing vessels from Quebec in 1867 totalled 1,041 of 590,120 tonnage.

On the first day of July, 1867, the "British North America Act" came into force, but for some months, and until the Dominion Parliament could enact new legislation the Public Departments were managed under the Acts in force in the provinces prior to Confederation, and by the officers then in their employ. The "Act Respecting the Public Works of Canada," 31 Vict., Chap. 12, was passed on December 21, 1867, and the Public Works Department came into being, under the direction of the Minister, the Honourable William McDougall.

In addition to continuing the administration of the works which had been under the charge of the Commissioners of Public Works of the United Provinces, there were added to his care the canals, the works in navigable rivers, and the railways of the provinces of Nova Scotia and New Brunswick. The construction of lighthouses was continued under the Department of Public Works but the management of these, as of the provincial vessels, was transferred to the Department of Marine and Fisheries. The greater part of the roads and bridges and certain public buildings was transferred to the local governments, but the construction of military and interprovincial highways, and of classes of public buildings appropriate to the Dominion service was reserved to the Dominion, and administered by the Public Works Department. The main additional responsibilities added were the Nova Scotia and the New Brunswick railways. The St. Peters Canal, Cape Breton, commenced in 1854 by Nova Scotia, was then about completed, this being accomplished in 1868 under Alex. McNab as Provincial Engineer. The lighthouses in Nova Scotia were an added responsibility, but harbour development had not been extensive, \$162,646.05 having been expended on 109 harbours. In New Brunswick the Apohaqui bridge was assumed. It is of interest to note that D. Fraser, mail carrier on the Matapedia Road, contracted to keep a section thereof in repair 83 miles in length, for \$800 per year.

Anticipating a future union of the British possessions in the North-west Territory with Canada, surveys had been carried on by S. Dawson, C.E., for the purpose of selecting the route of a road from Lake Superior to the Red River, and a report by the Engineer proposed the improvement of the navigable portion of the route so as to diminish as far as practicable and economical the distance to be travelled by land. Of the total distance of 443 miles, some $137\frac{1}{2}$ miles would be on land and the balance by water. To relieve the distressed people of the Red River the construction of the road from Fort Garry to Lake of the Woods was put under way. The balance of the works was later accomplished in large part, including provision for a lock at Fort Frances. The usefulness of the route was largely lost after the construction of the Canadian Pacific Railway, though it served as the route to the West during the North West rebellion.

Over the period of 12 years following Confederation in 1867, several undertakings of note were accomplished. The Intercolonial Railway was constructed and opened to traffic on July 1, 1876; the Prince Edward Island Railway was completed and opened to traffic on July 1, 1875, and as a result of the surveys carried out of the route of a railway to be built on Canadian territory and terminating at the Pacific Ocean, construction thereof was begun in 1875 and is now known as the Canadian Pacific Railway.

Following careful examination made in 1870, there was undertaken an improvement in the depth and other dimensions of the canals on the St. Lawrence route and on the Ottawa route, the improvement being executed

over a term of years. When in 1879 the Department of Public Works was divided into two Departments, to the new Department of Railways and Canals were transferred the railway and the canal activities of the Department of Public Works, and under the continuing Public Works Department were the public buildings, the ports, harbours, piers, dredging, slides and booms, telegraphs and military and interprovincial roads.

The channel of the River St. Lawrence to Montreal which had been deepened to 20 feet at low water with a width of 300 feet, was further improved and by 1878 a depth of 22 feet had been established, except between Cap Charles and Cap Levrard where it was necessary to take advantage of the tides. The Minister of Public Works entrusted this work to the Harbour Commissioners of Montreal, constituted in 1830. That body decided to continue the deepening to 25 feet, which work it accomplished in 1883 except between Cap a la Roche and Cap Charles, advantage having to be taken of the tide to pass that section. The late Sir John Kennedy was Chief Engineer to the Harbour Commissioners. It was in that year the Public Works Department was voted the first grant to commence the hydrographic survey from Montreal to Quebec.

At Quebec, two works of major importance were carried out under the immediate direction of the Harbour Commissioners, reporting to the Minister of Public Works, and with Woodford Pilkington, M.I.C.E., as resident engineer. The Lorne Graving Dock at Levis, 500 feet long and with a depth of 25.5 feet was constructed of Terrebonne limestone and Portland cement concrete, funds being found by grants from the Dominion and Imperial Governments supplemented by an amount raised by the Harbour Commission. The machinery, still in use though about finished, consists of two main pumps, 4 feet in diameter and 5 foot stroke, 15 strokes per minute, driven by 75 horse power steam engines. The Princess Louise wet dock and tidal harbour, at the junction of the River St. Charles and the St. Lawrence, at Quebec, had been decided on in 1874, and by 1882, the works enclosing the basins had largely been completed.

During the same period, the waterborne commerce of the Maritime Provinces had required improved and extended facilities, so that 102 ports, rivers and harbours had been improved in Nova Scotia; some 34 had been attended to in New Brunswick, and 19 in Prince Edward Island. The number of improvements in Quebec was 84, and in Ontario 60.

Noteworthy in their way are the reports by Sanford Fleming, Engineer-in-Chief, Canadian Pacific Railway, to the Minister of Public Works under date of April 5, 1879; of James B. Eads, Consulting Engineer, of Mississippi River fame, to the Minister on Toronto Harbour, under date of March 4, 1882; that of the Montreal Flood Commission in 1888 (Public Works report 1889-90).

The early development of the Western Provinces in 1882 may be judged from the extent of work carried out to that date. The Assiniboine River had been improved for navigation by the removal of boulders and the con-

struction of wing dams at an expenditure, since Confederation, of \$4,178.13, and the Red River from the United States boundary to Lake Winnipeg by the removal of boulders at the St. Andrews rapids, at a cost of \$6,234.90.

A report had been made in 1882 by Thomas Guerin, C.E., on the causes of the flooding of farm lands bordering Lake Manitoba, and the possibility of overcoming them, a problem not as yet successfully met; an early and interesting hydraulic and reclamation study.

In British Columbia, admitted to Confederation in 1871, there was undertaken the construction of a graving dock at Esquimalt, very similar to that constructed at Levis, and which constituted the only ship repair facility of that nature on the Canadian coast of the Pacific until the construction of the G.T.P. floating dry dock at Prince Rupert in 1918, and the New Esquimalt dry dock, completed in 1926. Harbour improvements in that province up to 1882 were confined to the Skeena, the Naas, the Cowichan, the Courtenay and the Fraser rivers, and to Victoria harbour.

The Minister of Public Works, in his annual report for 1886, expressed his feeling of encouragement in Canada's progress and his confidence in its future. He cites the expansion of trade and increase in revenue, and points with pride to the fact that whereas, from 1867 to 1882 there had been 73 public buildings constructed at an expenditure of \$10,369,383.91, and in the same period of 15 years \$8,869,663.33 had been expended on harbour and river activities, the Department, from 1882 to 1886, had built 88 new public buildings at a cost of \$5,609,473.39, and on 68 new piers, wharves and breakwaters had spent \$3,262,313.24.

Among the buildings were the Langevin Block in Ottawa, the first structure erected there by the Government since the original Parliament building and the two Departmental office blocks, and required to house the increasing staffs engaged in expanding government activities.

The deepening of the St. Lawrence and Welland Canal systems had resulted in larger vessels being used on the Great Lakes, and improvement of the more important Great Lakes harbours, by dredging, to a depth of 17 feet accounted for part of the expenditure.

A considerable fleet of dredging plant had been acquired, in the Maritime Provinces, in Quebec and Ontario; in Manitoba a dredge was engaged on the improvement of the channel of the Red River, the fishing and lumbering industries on Lake Winnipeg being actively prosecuted, a cut of 10 million feet of lumber being reported, fishing establishments fully equipped with freezers, etc., carrying on vigorously, these industries utilizing 12 steam vessels, with barges, of 1,471 gross tons.

The Ship Channel to Montreal had been in process of further improvement, and at the close of 1888 the project of deepening to $27\frac{1}{2}$ feet had been completed. At that juncture the responsibility for the channel was assumed by the Dominion from the Montreal Harbour Commissioners and the successive steps in its further improvement were under the Public Works Department, under which the $27\frac{1}{2}$ -foot channel was maintained as to depth.

widened and straightened, and in 1899 the project of a 29-foot depth of channel, 400 to 500 feet wide, was commenced. This had resulted from the low water years of 1895 and 1897 establishing that the 27½-foot channel had a dependable depth of 25 feet 10 inches, and the low water datum for future improvement was dropped still further, or by 10 inches below the lowest recorded level, that of November 1, 1895. At the end of the century considerable attention was being given by the Department to the question of ice breaking in the channel.

The graving dock at Kingston, on Lake Ontario, was completed for operation in 1891, providing a repair facility for the increasing number of vessels trading from the Welland Canal through Lake Ontario and the St. Lawrence River and its canal system to Montreal.

The earliest mention in Departmental reports of destruction by marine insects of timber works in sea water is in the report of damage to the pier at Digby, N.S., in 1882. Louis Coste, Chief Engineer of the Department, in his annual report for 1893 gives an account of the first use of creosoted timber, which was at D'Escousse and at Bayfield, N.S., and consisted of North Carolina yellow pine, with a retention of 16 pounds of creosote oil per cubic foot of timber, and treated at the Lehigh Valley Creosoting works at Perth Amboy, N.J., and at the Eppinger and Russell plant at Brooklyn, N.Y., by Hayford's process. He remarks that there were no creosoting plants in Canada, and advocated the establishment of government creosoting works, and the use of the Boulton process, developed in England and which he considered gave uniformly dependable penetration, which the Hayford process was not found to give. The establishment of creosoting plants in Canada since that time, treating successfully timber of Canadian origin has been a most valuable development, when it is considered that the teredo will completely destroy a large, untreated log in less than six months.

An early Canadian contribution to the literature is a paper before the Natural History Society of N.B., by E. T. P. Shewen, reproduced as Appendix 15 to the Public Works Annual Report for 1895.

The Yukon Gold Rush

The discovery of gold in Yukon territory and the world-wide prominence it brought to that territory was followed by a rush of people to that country, and the late Louis Coste, then Chief Engineer, was sent by the Department, in March, 1898, to study the best means of improving the water courses of the district. Navigation, by the water route from White Horse to Dawson City was the only means of access, and still remains the principal means, though supplemented by the modern facilities of travel by air.

The years immediately following were spent in effecting improvements to the route, and in the construction of lines of telegraphic communication with the outside, both of which activities still continue.

The Twentieth Century

At the beginning of the century it is recorded that over 800 works of harbours and rivers, and nearly 250 buildings were under direction of the Department; in addition there were 3,666½ miles of telegraph land lines and 208 miles of submarine cables, with 185 offices handling 76,410 messages in a year.

In the Maritime Provinces the requirements of navigation for terminal facilities at the major ports were a function of the railways, principally the Intercolonial, the activities of the Department being devoted to the smaller ports which, however, were of great use, as they still are to the population and the industries peculiar to that region.

While a similar expansion in the provision of small port facilities on the St. Lawrence and its main tributaries in Quebec was proceeding, the major activities were the completion of the newly adopted depth of 30 feet at 1897 low water, and 450 foot width for the channel to Montreal and the hydrographic survey associated with that waterway.

The eastward movement of the western grain crop had become of moment, elevators being erected at Goderich on Lake Huron, Collingwood, Meaford, Midland and Depot Harbour on Georgian Bay, and at Coteau Landing on the St. Lawrence. These, built by private interests had necessitated the deepening of the harbours to 20 feet, and the extension of the harbour works. Increased harbour area at Port Colborne, the Lake Erie end of the Welland Canal was provided by the construction of a breakwater to enclose a sheltered area of some 438 acres.

The importance the lumbering and fishing on Lake Winnipeg had assumed resulted in the construction of harbours at Hnaua and Gimli; and plans were in preparation for the dam at St. Andrews rapids to bring navigation to Winnipeg on the Red River.

The Columbia and the Kootenay rivers were in demand as routes into the interior of southern British Columbia, where settlement and mining development were active, and works were carried out to facilitate this commerce.

The Fraser River had from early days provided the route into the interior from the coast, and the Royal Engineers had been the first to plan and execute improvements, not only to the river channel but by the construction of the famous Cariboo Road. The lower reach of the river, from the Gulf of Georgia to New Westminster had been used with difficulty by larger, or ocean ships, and these difficulties were more pronounced as the sizes of ships increased with expanding trade.

This development, of a stable channel, of a river subject to heavy variation in flow, and meandering across about 5 miles of tidal flats which it has caused by deposition of eroded materials transported by the river, and subject to the action of an ordinary tidal range of 12 feet, has caused the engineers who have had to deal with it some anxious times. After

several years' attempts had not succeeded in stabilizing the channel, the city of New Westminster, in 1910, engaged J. W. Le Baron to investigate and report his findings. Mr. Le Baron proposed two reaction jetties, springing from the mainland and extending seawards to the edge of the bank of the delta. A commencement on the north jetty was made, but for some years after the first section was built divided opinion on the future course hampered progress. This was overcome by convening a Board of Engineers in the Department's service, who brought their experience of similar, though lesser problems of like nature to the solution of the situation. The services of W. A. Johnston, of the Geological Survey of Canada were obtained to study and report on the problem, and his results are to be found in (a) Memoir 125, Geological Survey of Canada, "Sedimentation of the Fraser River Delta," and (b) Memoir 135, Geological Survey of Canada, "Geology of the Fraser River Delta Map-Area."

The work has since then followed the plan then adopted, and a channel stable in depth and direction has resulted. As will be seen from Fig. 1, the north jetty is 25,800 feet or 4.88 miles long, and so far, as practically a single reaction jetty, has functioned with satisfactory results. This is cited as the outstanding instance of this type of problem in Canada.

Population

The warranty for the carrying out of the improvements in the nature of Public Works, as of other governmental activities rests basically on there being a population requiring that service for its well-being, and in the case of Public Works it is very definitely linked with the nature and extent of the natural resources of the country, with their production, and with the cheapness of transportation of the primary and manufactured products, else there would be no need of or warranty for these activities.

According to the census of Canada of 1666, the first modern census of record, the population of Canada was 3,215 souls, by 1685 it was 10,904 (including Indians in villages), and by 1700 it had passed 15,000. Lower Canada, Upper Canada and the Maritime Colonies, about 1791, had a population of 373,000, and by about 1840 this had increased to 1,535,000. During the fifties and sixties, population increased rapidly, especially in Ontario. This increase in population has continued, but is coupled with a distinct movement of population within Canada, from East to West. The following tabulation gives figures pertinent to this study.

Population of Canada in 1871 and for each decade to 1931

Population—	1881	1891	1901	1911	1921	1931
1871						
3,689,257	4,324,810	4,833,239	5,371,315	7,206,643	8,787,949	10,376,786
Increase	635,553	508,429	538,076	1,835,328	1,581,304	1,588,837
Per cent	17.23	11.76	11.13	34.17	21.90	18.08

Total increase, per cent—181.27

Illustrating the development of the West may be cited the separate figures of population of Manitoba, which from 25,228 in 1871 has grown to 674,911 in 1931, an increase of 2,675.25 per cent. Even at that the density of the population was only 3.19 persons per square mile.

In the opening decade of the century, the population increase was 34 per cent, the fastest rate of any country in the world, and in the second decade the gain was 22 per cent, only exceeded by Australia, and by a fraction of one per cent. Since Confederation, Canada's population has nearly trebled, gaining nearly four times as fast as the world as a whole.

The outstanding feature of the opening of the "last best West", resulted in a great acceleration in the expansion of population. At this juncture there occurred a great broadening of world credit, capital from Great Britain flowing in large amounts to undeveloped countries, especially to Canada, which received 2½ billion dollars within a dozen years, and a volume of immigration of over 2,500,000.

With the increase in population of almost unprecedented degree, the definite establishment of the West high among the World's producers of grain, the development of manufacturing in Canada, and the confidence in Canada's future so substantially expressed by the inflow of capital from Great Britain an added impetus was given to the provision of adequate Public Works to take care of the situation.

The western railway field was served by the Canadian Pacific from 1885, but its virtual monopoly of transportation of that area was invaded on the construction of the Grand Trunk Pacific from Lake Superior to the Pacific Ocean. The National Transcontinental as a rail route to facilitate the development of Northern Ontario and Quebec and give access to a winter port on Canada's Atlantic seaboard, and the Canadian Northern, virtually a third Transcontinental line, were also constructed.

The development of the Lakehead harbours on Lake Superior at Fort William and Port Arthur for transshipment of Eastbound grain and reception and dispatch of Westbound coal, iron, ore and manufactured products, and of the harbour of Saint John, N.B., as a winter port were the natural outcome of the railway expansion.

Saskatchewan and Red Rivers

Notwithstanding the expansion of rail facilities in the Prairie Provinces, the great use and convenience the waterways had been in opening up that area led to an examination being made of the possibility of utilizing the Saskatchewan River, Lake Winnipeg and the Red River as a route for economical handling by water of Eastbound grain and coal, and return of manufactured goods. The very complete surveys of the route from Lake Winnipeg to Edmonton, covering a distance of 941 miles, carried out from 1910 to 1915 under the Public Works Department did not indicate that the results anticipated would then obtain, and the project, so far as the Saskatchewan River is concerned has remained in abeyance.

Prior to the incursion of railways into the Western Provinces, the Hudson's Bay Company operated steamers on the route from the Red River to Fort Edmonton; one running from the Red River to Grand Falls, 260 miles, a second from Grand Falls to Carlton House, 400 miles, and a third from Carlton House to Fort Edmonton, 410 miles. It took about a fortnight to make the 1,073 mile trip.

The Red River-Lake Winnipeg route into the North was however improved by the construction in 1910 of a dam of the Caméré type which raises the level of the Red River by about 20 feet at its location, some 20 miles downstream or north of Winnipeg, and by about 6 feet at Winnipeg. It is the first of its type to be constructed on either of the American continents, and the type was chosen so that the permanent obstruction to the flow of ice and water would be a minimum. A navigation lock permits the passage of vessels past the dam, and the supporting structure of the movable dam carries a highway floor.¹

The Georgian Bay Ship Canal

The route from Montreal to the West from earliest days followed the Ottawa River and the Mattawa to the height of land, and Lake Nipissing and the French River to Georgian Bay, a route which avoided conflict between the French and their Indian allies, and the English and the Indians allied with them. As commercial development progressed the possibilities of this as an all Canadian route for water transportation were canvassed, and the appointment of Commissioners to survey the Ottawa River and country bordering on it, together with the waters lying between the Ottawa and Lake Huron was authorized by Chapter 57, Wm. IV, of March 4, 1837. In 1857, James Stewart, C.E., surveyed the route under Walter Shanly, C.E. Shanly's proposal contemplated locks 250 feet by 50 feet with 10 feet of water on the sills, and included 58 miles of canals with 372 miles of river and lake navigation. In 1859 T. C. Clarke, C.E., resurveyed the route, and proposed locks 250 feet by 45 feet, with 12 feet on the sills, the construction of dams to shorten the length of canal reaches, and estimated the cost, exclusive of enlargement of the Lachine Canal, at \$12,000,000.

The improvement of the then existing Ordnance canals as far up as Ottawa was undertaken and completed. Above Ottawa the canal from Chats Lake to Chaudiere Lake was commenced, but work was suspended in 1856, to allow reconsideration of the scale of improvement for navigation. The section of the project known as the Culbute Canal, between Bryson and Aberdeen, with 6 foot depth on lock sills, was commenced in 1873 and completed in 1876, but as the railway was at that time extended to Pembroke very little use was made of the improvement.²

¹Engineering Record, March 26, 1910. Engineering News, October 6, 1910.

²Appendix 70, Public Works Report 1867-1882.

The Montreal, Ottawa and Georgian Bay Canal Co. was incorporated by 57-58 Victoria, Chap. 103, in 1904, with authority to construct a canal of at least 9 feet depth, work to be commenced within two years, and to be completed within eight years. The Company's charter was kept alive by further legislation from time to time, but its final application for extension of time in 1927 was not granted, and it passed from the picture.

The Government, in 1904, charged the Minister of Public Works with the carrying out of a most complete survey and examination of the route, the survey to be of such a character "that there could be projected on the plans the best location possible for a canal at least 22 feet in depth, with a bottom width of 300 feet, from which profiles could be drawn and a correct estimate made of the amount and character of material in excavation and embankment, nature of various foundations, and final design of locks, dams, regulating works and other structures; also the right of way and definition of flooded areas."¹

Reporting to the Chief Engineer of the Department, the surveys and examinations, designs, calculations and all pertinent engineering studies were under the direction of the late Arthur St. Laurent, past president, E.I.C., as Engineer in Charge; the Montreal District, from the east end of Montreal Island to the mouth of the Gatineau River was under C. R. Coutlee, M.E.I.C., as District Engineer, whose district was extended westward in 1906 to the head of the DesJoachims Rapids; the Nipissing district, from the head of DesJoachims Rapids to Georgian Bay, was under S. J. Chapleau, M.E.I.C., as District Engineer.

The extent of the project may be better gauged from the fact that the length of the route investigated, from Bout de l'Île, at the foot of Montreal Island, to the western end, the mouth of the French River at Georgian Bay, is 451 miles.

Very complete examinations of the streams of the watershed were made by the Hydraulic Engineering branch; a control Precise Levelling was carried out to check finally the transfers already made of the U.S. Coast and Geodetic determinations, and carry the system all along the route; a systematic examination was made by test borings to guide in determining the economically suitable locations of channels and of structures.

The report of the Board of Engineers, dated January 20, 1909, advised the Minister of Public Works that a 22 foot waterway for the largest lake boats (600 feet by 60 feet by 20 feet draft) could be established for \$100,000,000, with an annual maintenance cost of \$900,000. It submitted plans for a canal with 27 locks varying from 5 feet to 50 feet lift, connecting 23 navigable pools of various lengths; the locks to be 650 feet long, 65 feet wide, and 22 feet deep.

¹Georgian Bay Ship Canal Survey report, 1909.

The project has not been proceeded with, the Government in 1912 deciding to proceed with the Welland Ship Canal for deep draft vessels, that work being opened to traffic in 1930.

The Georgian Bay Ship Canal survey, however, resulted in a very complete knowledge of the water power resources of the Ottawa River and its principal tributaries being obtained, the computed amount of power available being 1,000,000 horsepower.

At the Chaudiere Falls section of the Ottawa River, between Ottawa and Hull, water power leases had been granted under the Government of Canada prior to Confederation; at Confederation these fell to the lot of the Dominion to administer. In subsequent years difficulties arose between the various lessees over apportionment of the water available, and to clarify the situation it was arranged that the lessees would build a compensating dam above the Chaudiere Falls, and that the Government would construct storage and regulating dams, at the foot of Lake Timiskaming, and at the foot of Quinzé Lake, both on the upper Ottawa, and at the outlets of Kipawa Lake.¹

On the Georgian Bay slope Lake Nipissing drains out through the French River, and to benefit navigation, at the same time to do away with the annual cost of dredging in channels and at wharves, dams, with stoney sluices in the main outlet, and with stoplogs in the other, were constructed at the Chaudiere rapids, the outlet of the lake into French River. The regulation of Lake Nipissing in this manner was an integral part of the Georgian Bay Ship Canal proposal above referred to.

The foundation conditions at the only available site for the regulating dam at the foot of lake Timiskaming were distinctly bad, the river there following a deep cleft in the country rock, probably a fault, which had been filled with boulders of great size, and sand. Considering the class of equipment then available for construction, and the comparative inaccessibility of the site, the dam as then built, of stop log sluices on a wide concrete foundation and founded on material of the nature mentioned, was a credit to its builders. Subsequently the action of the discharge at high flows past the dam site, which reach 110,000 c.f.s., scoured out the foundation on which the concrete mattress had been laid, and in 1931 it became necessary to reconstruct the Quebec channel dam. A section of the dam as reconstructed is shown in Fig. 2; it incorporates the patented "dentated sills" of Dr. Rehbock, to overcome the scouring action, has a much heavier section, and is functioning satisfactorily.

An unexpected situation developed during the building of the Quinzé and the Kipawa Lake dams. Concrete was used in their construction, and all the precautions, until then developed, were used to check the aggregates. When the works were mostly completed it was seen that the concrete had not developed the strength expected, and examination showed the cause to

¹Ottawa River Storage report, Sessional Paper 19a, of 1911; 19 of 1912; and 19 of 1913.

be the presence of a transparent coating of organic matter on the particles of the aggregate used. This is insoluble in water, cannot be detected by the eye, but can be removed by a 3 per cent solution of commercial caustic soda. Its presence is to be suspected in deposits of a siliceous nature, but will not be found where lime is present. That part of the structure built with aggregates so treated is sound, but the greater part built before the trouble was detected has given trouble from disintegration, and the Quinze dam will require replacement from this cause very shortly. As far as known to the writer this circumstance had not previously been experienced elsewhere.

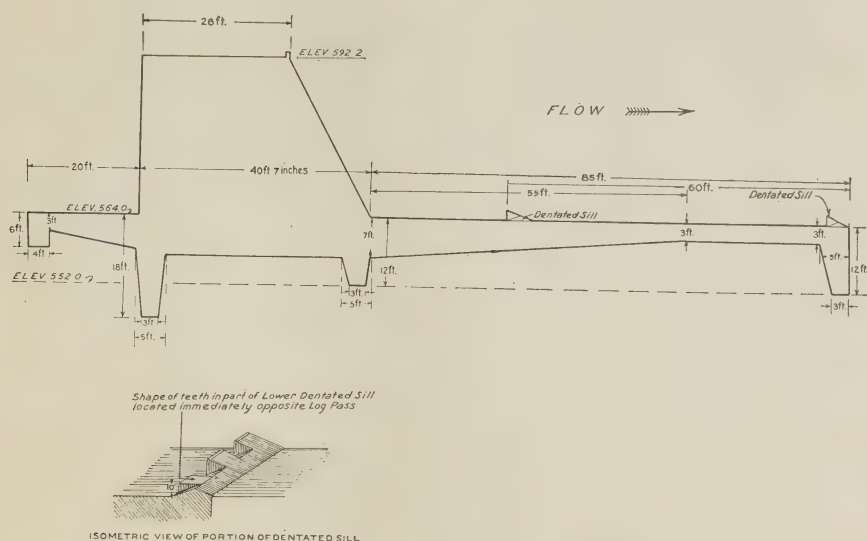


FIG. 2.—Cross Section of Dam. Temiskaming, Que.

The Grain Export Trade

The grain trade of Canada now, and in the recent past, has played an outstanding part in the development of Canada, and indications are that it will continue to do so. In the movement of the important bulk commodity water transportation has largely shared, and the provision of harbours for the accommodation of ships has largely devolved on the Department of Public Works.

Grain, a pioneer crop, has been exported from the early days of the French regime; in 1754 wheat exports had grown to 80,000 bushels, and in 1734 there had been established some 118 flour mills. The market was mainly in the West Indies and Newfoundland. Following the British occupation a trade developed with Great Britain, but also with Mediterranean countries, the colony taking in exchange the products of those countries. By 1774 the exports had reached 460,818 bushels, but the trade declined

for some years, due principally to the American revolution; it gained impetus during the Napoleonic wars, declining again during the succeeding years with variations ascribable to poor crops, internal dissention in Canada, and imposition of protective duties by the British Government. Despite the vicissitudes it encountered, the grain trade continued, and with the opening up of Upper Canada, was given decided impetus. The production in that area of wheat was—

	Bushels
1851..	12,682,550
1861..	24,620,425
1871..	14,233,389
1880..	27,406,091
1882..	40,921,201

The Ontario production for some years has been about 40,000,000 bushels per annum, and that of Quebec about 1,000,000 bushels, both becoming importers to meet their deficiency.

The early development of harbours at Owen Sound, Collingwood and Goderich on Lake Huron, Port Stanley on Lake Erie, and Whitby, Oshawa and Cobourg on Lake Ontario, among others, reflects the influence of the settlement of the Province on the production of grain, and its export. The flow of grain is now reversed, western province products now being handled at Collingwood, Midland, Owen Sound, Goderich, Toronto and Sarnia for local consumption in Ontario as well as for export and milling in transit. At Kingston at the foot of Lake Ontario, the cargoes of lake steamers, limited in draft to 14 feet by the Welland Canal, were transferred to a barge fleet for transfer to Montreal and made that port an important point in the grain movement. In later years the canalers went through to Montreal; since the completion of the Welland Ship Canal, upper lake freighters have access to Lake Ontario, and Kingston has again become, with Port Colborne, Buffalo and Prescott, an important grain transfer point.

The volume of the grain trade to which we are accustomed has followed the linking of the West with the export markets, and the completion of the Canadian Pacific Railway line from Port Arthur and Fort William to Winnipeg in 1883. The quality of Manitoba wheat had been recognized before that, but the difficulties attending transportation south, up the Red River by vessel to the railway in Minnesota, thence to Duluth, and by vessel again down the Great Lakes to Sarnia were practically prohibitive. Winnipeg obtained its first rail connection in 1879, south to Minneapolis; the first shipment to Great Britain was made in 1877, leaving Halifax on January 12, 1878.

The first shipment of grain from the Lakehead was in 1883, when James Richardson & Sons loaded 10,000 bushels on the steam barge *Erin*, the grain being loaded by wheel barrows and horse carts, and dumped into the vessel's hold. The schooner *Sligo*, in 1884, carried the first cargo of grain handled through a Lakehead Elevator, the Canadian Pacific "King" elevator completed that year, and having 350,000 bushels capacity. This

elevator, later known as the "Horne," then "Gillespie," is operated as "Pool Terminal No. 2." While none of the original structure exists, it is noteworthy as having the first concrete tanks built in Canada, of 500,000 bushel capacity, erected in 1903-04.

The growth of elevator storage capacity at Port Arthur and Fort William has been:—

Year	Number elevators	Storage capacity	Year	Number elevators	Storage capacity
		Bushels			Bushels
1883.....	Nil	Nil	1910.....	15	25,700,000
1884.....	1	350,000	1915.....	27	43,785,000
1885.....	2	1,350,000	1920.....	30	54,185,000
1890.....	4	4,500,000	1925.....	35	64,705,000
1895.....	4	4,500,000	1930.....	32	88,830,000
1900.....	4	4,500,000	1935.....	30	92,680,000
1905.....	7	12,500,000	1937.....	30	92,680,000

The shipments of grain from the Lakehead harbours by water has been:

Year	Bushels	Year	Bushels
1883.....	10,000	1918-1919.....	108,537,469
(No further figures available until 1899-1900)		1919-1920.....	106,176,480
1899-1900.....	16,086,582	1920-1921.....	178,140,888
1900-1901.....	5,791,222	1921-1922.....	228,317,735
1901-1902.....	27,793,200	1922-1923.....	277,654,560
1902-1903.....	40,036,223	1923-1924.....	342,620,929
1903-1904.....	28,897,667	1924-1925.....	234,055,338
1904-1905.....	28,444,645	1925-1926.....	326,773,631
1905-1906.....	54,438,527	1926-1927.....	282,515,519
1906-1907.....	64,314,134	1927-1928.....	308,262,391
1907-1908.....	47,743,336	1928-1929.....	363,974,696
1908-1909.....	65,237,160	1929-1930.....	164,945,334
1909-1910.....	88,514,501	1930-1931.....	222,925,956
1910-1911.....	85,247,178	1931-1932.....	181,657,533
1911-1912.....	115,490,263	1932-1933.....	203,013,281
1912-1913.....	150,342,669	1933-1934.....	169,392,891
1913-1914.....	186,056,554	1934-1935.....	155,706,873
1914-1915.....	101,213,397	1935-1936.....	206,155,692
1915-1916.....	330,813,448	1936-1937.....	178,711,386
1916-1917.....	199,677,065	1937-1938.....	111,110,183
1917-1918.....	126,223,828	1938-1939.....	217,335,621

(Crop years cover the period from Sept. 1 to Aug. 31, to 1923. 1923-24 covers an 11 months period to July 31; and all subsequent years are from Aug. 1, to July 31).

At Port Arthur the harbour has been reclaimed from the open lake by the construction of breakwaters, with the harbour area improved for ships by dredging the sheltered area thus created.¹ At Fort William, the development has followed the water course of the Kaministiquia River, which

¹ Breakwater construction in Port Arthur Harbour, by F. Y. Harcourt, M.E.I.C., in the Engineering Journal, April 1931.

together with its branch outlet, the "Mission" have been widened to 600 feet and deepened to 25 feet. The "McKeller" outlet has been similarly widened and deepened but the improvement extends to the outlet only, and not into the lake.

The harbours, serving like varieties of commodity movements side by side—grain, flour, pulp and paper eastbound, and coal and package freight westbound, offer an excellent opportunity for comparison of the two types. This is beyond the possible limits of this paper, but it may be remarked that the more recent developments have apparently been shared about equally by the two harbours.

In the development to date some 48,150,000 cubic yards have been moved by dredging at prices prevailing from 9c. per cubic yard, scow measurement, in 1907, to about 18c. per cubic yard, situ measurement, recently; and in the rubble mound breakwater extending southwards 12,700 feet from Bare Point at Port Arthur some 3,023,376 tons of rock have been placed as the work has progressed from 1911 to date. (Fig. 3).

Although the Panama Canal was opened to traffic in 1914 the influence of that cut-off in the route between Europe and Asia or Australia, or in the route between the western coast of America and Europe, particularly in the grain and the lumber trades, was not apparent for some time. The first, experimental, shipment of 100,000 bushels of grain from Vancouver to Europe in 1917 demonstrating the feasibility of that route for grain shipments, has led to increasing amounts being forwarded, and to the establishment of elevator and other facilities at Vancouver, New Westminster and Prince Rupert.

Vancouver has now a combined elevator storage capacity of 17,843,000 bushels, and shipments reached 96,869,841 bushels of all grains, in the 1932-1933 crop year.

With the construction of the National Transcontinental Railway, the desire for Canadian winter ports with accommodation for ocean shipping on the Atlantic seaboard was met, in part, by the carrying out, under the Government Railways, of the Ocean Terminals at Halifax. The existence and suitability of Saint John, N.B., as a winter port was recognized in the undertaking of extensive deep water piers, improvement of the entrance channel by dredging, and the construction of a graving dock, capable of accommodating the largest ships then in existence or contemplated. The wharves then existing at Saint John were for the greater part the property of the city, the Intercolonial Railways having provided one structure. This program was carried out under the Department of Public Works, and, until the formation of the Saint John Harbour Commission, in 1928, all Dominion Government commitments in that harbour were entrusted to the Department.

On the Pacific Coast the port of Vancouver served as Canada's sole outlet of major importance until the terminus of the Grand Trunk Pacific Railway was established at Prince Rupert. The importance of fostering

ade with the Orient was recognized by the Government undertaking the improvement, by dredging, of the entrance to Vancouver. A large bucket ladder dredge was built in Scotland, and was operated from 1910 to 1918, deepening to 35 feet at low tide, from a natural controlling depth of 10 feet, and in widening to 1,200 feet the channel entrance to the harbour; in this operation some 4,100,000 cubic yards were removed. The Department also carried out the construction of the "Lapointe" pier, a timber-pile structure protected against the ravages of marine insects by a sheathing, 18 inches thick, of reinforced concrete, which has proven quite satisfactory.

The port of Victoria, capital of the Province, and chief city of Vancouver Island being a port of call for the trans-Pacific liners, as well as for other ocean vessels, had been one of the earliest ports to be improved, the colonial government having commenced its development prior to the entry of the Province into Confederation. The Dominion continued the improvement, which for many years consisted in deepening the harbour by dredging. To extend the deep water wharf accommodation, all of which was privately owned, the Department, in the period 1913 to 1916, constructed the Rubble mound breakwater as a protection to vessels lying at the Ogden Point deep water piers, also undertaken by the Department, now the site of the grain elevator at that port, and operated by the Canadian National Railways.

The improvement of the St. Lawrence River Ship Channel continued under the Department of Public Works until 1904, when these activities were transferred to the Marine Department, now the Department of Transport. F. W. Cowie was Engineer-in-Charge of the Ship Channel activities, and G. J. Desbarats was Director of the Sorel Ship Yard. During this period the Department constructed the Jacques-Cartier pier at Montreal, P.Q., completed in 1906, and a grain elevator, with wharf section 15, both works under the charge of Arthur St. Laurent, later Chief Engineer of the Department, and President of the Engineering Institute of Canada.

The problem of meeting the requirements for transportation facilities in Canada were very pressing, and a Royal Commission on Transportation was created in 1902, and submitted its report to the Minister in 1904-05.¹ As transportation occupies a pre-eminent place in Canada's domestic economy, the report presents a picture of conditions as at that time, and reflects the trend of thought on this important subject.

In Quebec harbour development of shipping requirements was met by the construction of a wharf at Point à Carcy, 1,460 feet long, with an available depth of 42 feet at low tide. This work, commenced in 1902, was carried out in 5 sections and completed in 1911, under A. R. Decary, Past-President, E.I.C., as Engineer-in-Charge.

¹Report of Royal Commission on Transportation, Sessional Paper No. 19a, 1906.

The increasing importance of Three Rivers as a manufacturing centre, and as a point for trans-shipment of commodities to and from the rapidly developing and important St. Maurice Valley, was met by the construction, completed in 1907, of a wharf on the St. Lawrence River with a length of 1,968 feet, and a depth at low water to accommodate ocean vessels.

The extensive territory in Quebec, south of the St. Lawrence River and dependent on Quebec harbour as a point of transfer between ship and shore was accommodated by a deep water wharf at Levis, 903 feet long; the needs of the territory have now outgrown the capacity of the wharf and a further deep water wharf is presently under construction by the Department.

The industrial possibilities of Toronto harbour being recognized by the City, a scheme for improvement of the eastern portion to provide sites for industrial purposes was drawn up. Access to Toronto and to other ports on Lake Ontario from the upper lakes, and from the Lower St. Lawrence was limited to vessels of 14 foot draft by the Welland and the St. Lawrence canals. Provision was made, when the Department reconstructed the western entrance to this harbour, in 1908 to 1912, not only that the location be suitable for use by, but that ample depth could be made available for larger ships should the Welland or the St. Lawrence canal system be enlarged. This was done in 1929, to coincide with the opening of the Welland Ship Canal, a depth of 27 feet being provided.

Following the reconstitution of the Toronto Harbour Commission the City undertook and has carried out under that body an effective scheme of harbour improvement, the Commission developing a very complete system of wharfage on the harbour. The Dominion Government, under the Department of Public Works undertook to develop the eastern or Ashbridges Bay section of the harbour by the construction of a wharfage system, and dredging. Work continued from 1912 to 1926, and involved the building of some 16,705 lineal feet of revetment bordering a ship channel and turning basin and providing a large area with the advantages of both rail and water transportation. The Dominion Government's contribution included also a breakwater, 18,600 feet in length from the Western entrance to the harbour to the Humber River.

The subsequent completion of the Welland Ship Canal, and increased trade by water has resulted in these facilities being fully availed of. In 1934 to 1936, under the Public Works Construction Act the Dominion constructed the Marginal Way dock, and completed section 10 of the original development.

Burlington Bay, on which is situated the important manufacturing city of Hamilton, is separated from Lake Ontario by Burlington Beach, through which the Government has maintained a channel for over 100 years. As water borne commerce increased with larger and deeper draft ships requiring accommodation, the channel was deepened and widened to coincide with the Welland Ship Canal, provision being made that a depth of

27 feet may ultimately be furnished. Highway traffic across the canal, probably of higher intensity than on any other route in Canada uses the double leaf bascule bridge which replaced the earlier bridges, they in turn succeeding the original ferry.

The growth of traffic on the Great Lakes is indicated in the table on page 26, which records, for the years shown, the traffic handled through the canals at Sault Ste. Marie, Ontario and Michigan.

As the completion of the Welland Ship Canal would allow vessels of upper lake capacities access to Lake Ontario and transfer the eastern transfer terminus from Port Colborne, on Lake Erie to a port on Lake Ontario level the Department selected Prescott as the most logical place of trans-shipment and erected there a grain elevator of 5,500,000 bushels capacity, equipped for transfer of grain from upper lake to canal boat, or to rail. The channel from Lake Ontario to Prescott was improved to St. Lawrence Deep Waterway dimensions as a joint undertaking with the United States, each country carrying out the improvement in its own territorial waters.

The instances cited above are from the larger and better known harbours. With the development of the larger national harbours a desire developed at each centre for a means whereby those locally interested might share in the plans for its harbour, and Harbour Commissions were provided for by legislation, the financing for capital expenditures being by loans from the Dominion. . In this way the activities of the Department of Public Works largely ceased at these places, except for improvement or maintenance of main entrances thereto, by breakwaters, channel piers, or dredging. By recent legislation, after the report of his study of conditions made by Sir Alex. Gibb, M.I.C.E., control of harbours formerly financed by Dominion loans has been vested in the National Harbours Board under the Minister of Transport.

Harbour and River Development

The requirements of the people of Canada in carrying on their business where water transportation is a factor have, however, been continuously met under the Department of Public Works, the growth in this direction being indicated in the following table, and in the graph of yearly expenditures under the Department. (Fig. 4.).

1882.....	199	works	1925.....	2,221	works	active
				28	"	abandoned
1892.....	387	"	1932.....	2,976	"	active
				281	"	abandoned
1902.....	571	"	1934.....	3,164	"	active
				327	"	abandoned
1912.....	1,244	"				

GROWTH OF TRAFFIC THROUGH SAULT STE. MARIE CANALS

Year	Passages by		Net registered tonnage	Total tons freight	Coal	Wheat	General merchandise	Per cent freight carried by steamers
	Steamers	Others						
1855.....	149	44	106,296	14,503	Tons 1,414	Bushels None	Tons 5,690	.....
1867.....	466	839	556,899	325,357	22,927	.....	33,632	.....
1887.....	5,968	3,387	4,897,598	.....	1,352,987	23,096,520	344,586	50—1887
1897.....	12,029	5,142	17,619,933	18,982,755	3,039,172	55,924,302	579,048	69—1897
1907.....	17,245	3,192	44,087,974	58,217,214	11,400,095	98,135,775	1,022,654	91—1907
1927.....	17,096	1,663	64,325,362	83,354,064	17,107,500	330,898,158	802,646	98—1927
1935.....	11,754	1,206	41,566,253	48,293,208	9,161,730	179,603,288	1,022,526	99—1935

Since the general conception of the Prairie Provinces is that of a vast field of grain it is worth noting that in 1934 there were 65 active works under the Harbours and Rivers division, and that 11 works of this category, previously carried out had been abandoned.



FIG. 4.—Expenditures under Public Works Department, 1866-1936.

Fisheries

The earliest travellers arriving at Canada's shores must have looked about to find what food could be had to augment their depleted stores, and on which they could depend while establishing their homes. The abundance of fish served this purpose most admirably, but the extent of the resources was not dreamed of.

We now know that from Grand Manan to Labrador is a coast line of over 5,000 miles, that the Gulf of St. Lawrence is over 80,000 square miles, and the Bay of Fundy over 8,000 square miles in area, and with other waters comprise an area of fully 200,000 square miles of fishing grounds. The area of the Great Lakes in Canadian territory is some 34,000 sq. miles in extent; in the Prairie Provinces, Lakes Winnipeg, Winnipegosis, Manitoba, and Athabasca, have a combined area of 16,359 sq. miles, and Great Bear and Great Slave lakes, in the Northwest Territories, add 22,830 sq. miles to the list. The coast line of British Columbia is 7,180 miles in length.

In 1844 the fish catch was valued at \$125,000; by 1860 it had passed \$1,000,000; in 1887 it was valued at \$18,386,103, of which the Prairie Provinces contributed \$129,084, and British Columbia \$1,974,887; in 1935 the value was \$34,427,864, British Columbia's fisheries accounting for \$15,169,529, and the Prairie Provinces and Yukon for \$1,756,860. In the latter year the invested capital was \$43,617,888, and 82,918 persons were employed.

The value of the products of this industry exported in 1935 was \$24,859,486, shipments going to 87 countries, and is exceeded only by the export fisheries trade of the United Kingdom and Norway alone.

From the very nature of their calling fishermen are the most dependent on harbourage, and are generally best served by harbours of moderate dimensions situated within reasonable distance of the fishing grounds and to their homes, at which their catch may be processed, their gear and boats sheltered and repaired, and from which their product may be forwarded to its markets.

The engineering problems in the development of fishing harbours do not arise out of the building of structures so much as from the varying local conditions of the nature of the coast, exposure to storms, tidal or other current direction and strength, the variation in level and of winter weather conditions, specially the formation of, and liability or otherwise of mass ice movement. Problems of the local availability of construction materials, the prevalence, or otherwise, of teredo or limnoria in sea water, of the probable length of life to be required from the works are of another, though not necessarily secondary order.

These problems were obstacles encountered by the engineers from the inception of harbour works in Canada's early history, and while we are still struggling to understand and master them, we have the benefit of their experience, and mistakes, the benefit of the much greater number of places where works have been, and are being undertaken, and of the records of studies of results, the opportunities of discussion with technical officers of other branches of the Government who have observed and studied the problems from other angles of approach, and of access to a literature which the earlier engineers did not have.

It is from the experience gained from observation during the development of the smaller harbours that there has been possible the progress made to the present day deep sea harbours and harbour works. The shipment by water of assembled cargoes of fish products, of lumber, of coal, or ores and other mine products, of agricultural products, and of manufactured products, has demanded from time to time the use of increasingly larger numbers of vessels of greater dimensions, steam, and later motor propelled vessels have invaded and almost displaced in their field the sailing vessels formerly used in the transport of commodities, and harbour works and facilities have had to keep pace with the demands of trade.

Among these movements of commodities by water, and which, it may be remarked, vary in amount and direction of movement from time to time, or may come into being and after a period fade out of the picture, all as economy of transport and market demand will change, are many and of varied interest.

Since in the movement of these commodities, raw or manufactured, transportation by water at some stage usually enters, it may be opportune to give some figures indicating the extent of their bearing on the economic life of the country.

Accessible stand for saw timber in Canada, 245,313 million feet b.m.; Canadian pulpwood used in mills, in 1934, in Canada, 41,752,685 cords; pulp production, in 1934, in Canada, 3,636,355 tons; value \$75,726,958.

Paper production in 1934, in Canada, 3,069,516 tons, \$120,892,225.

Sawmill products, in 1934, in Canada, value \$54,822,439.

Coal produced in 1935, in Canada, 13,864,577 tons; value \$41,888,528.

Coal imported in 1934 into Canada, 12,974,959 tons; value \$35,065,380.

Gypsum produced in Nova Scotia and New Brunswick, in 1934, 408,685 tons, \$592,753.

DOMESTIC EXPORTS

	1890	1935
	\$	\$
Wheat.....	388,861	132,441,685
Newsprint.....		82,147,844
Wood pulp.....	168,180	25,869,296
Planks and boards.....	17,637,308	24,900,902
Fish.....	8,099,674	22,411,413
Wheat flour.....	521,383	18,386,040
Furs, raw.....	1,874,327	14,897,968
Fruit, chiefly apples.....	1,073,890	10,496,002
Pulpwood.....	80,005	7,131,238
Timber, square.....	4,353,870	1,707,425
Coal.....	2,447,936	1,527,011
Potatoes.....		848,185

While we are likely to think of Halifax and Saint John as Canada's eastern winter ports, of Montreal and Quebec as Eastern summer ports, and of Vancouver, Victoria and Prince Rupert as the western outlets, these are after all mainly the seaboard harbours through which our foreign commerce flows. In the collection of the manufactured or of the primary products for export, and in the distribution of imports from abroad, the lesser or secondary harbours are most necessary, and these play possibly an even greater part in the much larger internal trade of the country.

The illustration, Fig. 5, indicates the routes of the regular coastal services given between the Ports of the Maritime Provinces; in addition to these regular services many vessels are engaged in a coastal "tramp" trade, and there are many of these and other ports from which shipments have been carried directly overseas for many years. Very similar trade routes exist between Montreal and Quebec and harbours on both the south shore of the St. Lawrence and the Baie des Chaleurs, and on the north shore of the St. Lawrence extending eastward to Newfoundland and Labrador. Increasingly extensive exchange of goods and commodities is being made by ships between Rimouski and Matane on the south shore and ports on the north shore of the Gulf of St. Lawrence as that section of the country continues to develop.

The development of the country above Montreal on the St. Lawrence-Great Lakes Basin has seen interesting changes in transportation. Before the Grand Trunk railway was opened to Toronto in 1854 practically all goods moved in and out by water. The railway provided a competitive route, and shared with the water route in the expanding trade, but the keenness of the competition forced the Railways to give a lower rate during the navigation season than during the winter or season closed to navigation.

By improved services the railways had secured the major part of the business until higher rates were forced on them by higher costs, and we have had for some years a distinct revival in carrying of package freight by this water route, notwithstanding the additional competition offered by the more recent highway truck service.

Very similar to the coastal services in the Maritime Provinces are those on the Pacific Coast. With Vancouver, Victoria or Prince Rupert as termini, coastal boats ply on schedule to ports on the Gulf Islands, on the Inland passage north to Alaska, and on Vancouver and the Queen Charlotte Islands, carrying cargoes of goods brought to the main ports for distribution, and collecting products of Canadian industry for overseas export, or for consumption elsewhere in Canada. And also, similar to the Maritimes, shipments proceed by ships, direct from many ports; coal from Nanaimo, paper from Powell River, Ocean Falls, or Port Alice, or lumber from Chemainus, Crofton, the Fraser River, or Port Alberni, to mention only a few.

The accessibility of large deposits of gypsum, to the waters of the Bay of Fundy, and those around Cape Breton, and the demand for this product for use in the building industry in New England, and in Great Britain, has brought about increasing shipments to those markets, direct from harbours near the miners or quarries and in ships of up to 24 feet draft.

Prince Edward Island, in climate and soil, is peculiarly adapted to produce potatoes of high quality, and the concerted and sustained efforts of its people have opened up a market in the West Indies, and in the Southern States, particularly for seed potatoes. The provision of shipping piers, and of frost-proof assembly warehouses at the main P.E.I. harbours of Georgetown, Souris, Charlottetown and Summerside, was a government aid provided through the Public Works Department.

The communities which have come into being as the coal mining and steel and other industries have developed at the Sydneys and in the Pictou-New Glasgow areas in Nova Scotia have to depend on outside sources for their food stuffs and other necessities. The farm produce of Prince Edward Island finds an outlet through its conveniently located smaller harbours, and small trading vessels, which carry return cargoes of coal, lumber, and merchandise. Even gravel, for road building and other construction purposes, is largely imported into the Island, from accessible supplies at adjacent Nova Scotia ports where it has largely only a nuisance value.

The increase in overall consumption of forest products has been due to the phenomenally rapid rate of development of the wood pulp and paper industry, and this has also required the location of mills where plentiful supplies of water and power were available, to which supplies of pulpwood and coal can be brought economically, and from which the finished product may be shipped to market with full regard for the same factor. The majority of mills find it either necessary or advantageous to purchase pulpwood supplies, and the transportation of this is most economical by water. The greater part of the exports of pulpwood are carried in this way. Maritime provinces supplies not consumed in that region by the paper mills at Liverpool, Bathurst or Dalhousie, or the pulp mills at Sheet Harbour or Hantsport, are absorbed by mills in New England, Quebec, and Ontario. The resources tributary to the St. Lawrence (North Shore), Baie des Chaleurs and South Shore are used at mills in Quebec, Ontario, and at Erie, Pa. The development at Comeau Bay (Manicouagan) of a paper mill by the Ontario Paper Co., is the first of its kind below Quebec, on the North Shore, although pulp mills at Clark City and Murray Bay have been in operation for some years.

Notwithstanding its immense reserves of coal, computed at 1,234,289,000,000 metric tons, Canada imports about 50 per cent of its coal consumption, due to the lack of any native supplies in the consuming provinces of Ontario and Quebec, the distance of these areas from the Maritime Provinces or the western coal areas, and to the comparatively economical access of coal from Pennsylvania, Ohio or West Virginia to the Great Lakes. The Great Lakes movements of coal to the harbours at Prescott, Kingston, Belleville, Cobourg, Oshawa, Toronto and Hamilton on Lake Ontario, to Port Maitland, Port Burwell, Port Stanley and Rondeau on Lake Erie, to the Georgian Bay ports of Midland, Owen Sound, Byng Inlet, Key Harbour, Little Current and Sault Ste. Marie on Lake Huron level, and to the harbours of Port Arthur and Fort William on Lake Superior are, with the movements across the Niagara and Detroit frontiers, the means of the fuel supply for this considerable consuming area with its large proportion of the manufacturing, including the paper making plants, and in increasing proportion of the mineral developments in Canada.

The factors influencing the location and development of harbours in Canada are many and diversified. On the Bay of Fundy the tides have a range of from 15 feet at Yarmouth, through $27\frac{1}{4}$ feet at Saint John, to $45\frac{1}{2}$ feet at Hopewell Cape, and $51\frac{1}{2}$ feet at Burntcoat Head. In fact so extensive is the tidal range on the inner reaches of the Bay that at the harbours there is no true tide. Vessels berth at high, and lie aground during the lower portion of the tidal range, so that facilities in the form of "gridirons" have been developed, in which vessels may ground much as if they were in drydock. These can be seen at Port Williams, an apple shipment port for the Cornwallis valley, and at Windsor, a lumber and gypsum shipping port for the Midland region. At other ports where this facility is not added the

barges or schooners ground on the shingle which is very prevalent, and is the cause of most of the difficulty encountered in keeping approaches to piers and vessel berths in satisfactory condition.

The Atlantic coast of Nova Scotia is of quite a different character, being deeply indented and generally rocky, and with the larger rivers of the province draining towards that coast from almost the opposite side of the peninsula. Notable exceptions are the Annapolis and Cornwallis which discharge into the Bay of Fundy waters. Harbours on this coast are generously provided in nature, there being possibly no finer example than that of Halifax. The facilities provided for fishing and lumbering industries take the form of channel improvements by dredging, and the construction of piers and breakwaters. Yarmouth Harbour has been greatly improved by dredging, and is the port through which much of the trade between Nova Scotia and Boston and New York is carried. The Eastern Steamship Company's ships on this service carry over 70,000 passengers per annum, and cost about \$7,500,000. The Port of Lunenburg, the centre of the salt bank fishing industry, is a port serving a different class of industry, which has been similarly improved. An example of the permanency of concrete in sea water will be found in the breakwater in Liverpool Harbour, at Brooklyn, where the Mersey Paper Co. is established, and where a concrete breakwater, standing in 30 feet of water, was constructed over 20 years ago.

Conditions of a different nature are found on the north coast of New Brunswick, but they are largely similar to those on Prince Edward Island and the Magdalen Islands. The tidal range has lessened, to between 3 and 5 feet, the shipping season is curtailed by ice in winter, whereas the outer part of the Bay of Fundy and the eastern coast of Nova Scotia are practically ice free. The most important difference, from the standpoint of harbourage and harbour work is that, on account of the country rock being sandstone, and that generally of a fairly friable nature, the action of the seas, of frost and other natural forces has formed immense quantities of sand and this in turn, by the action of wave and tidal currents, and the winds, has resulted in wide mouthed and shallow bays being formed, generally negotiable by only the smaller classes of fishing boats or smacks. It is under these conditions that the ingenuity of the engineer finds an opportunity of trying to form a stable harbour in the midst of naturally unstable local conditions.

The Quebec coast of the Baie des Chaleurs, westward of Gaspé Harbour, contains many interesting examples of the action of river and of ocean currents on the formation of the coast line, their influence on the location and type of harbours, and of the adaptation of engineering works thereto. The shore is generally abrupt, and of limestone or conglomerate, the drainage of the easterly slope of the Shickshock mountains by the Cascapedia, Bonaventure, Grand and other rivers has eroded through the geological formations, and it is mainly where the rivers debouch that harbours have necessarily become established. The tidal and wind induced currents in the

Baie des Chaleurs have continued the erosion of the abrupt shore line, and move the eroded material along shore, resulting in the formation of the "barachois" found at Carleton, at Paspebiac, and at New Carlisle. (Fig. 6.) The barachois at Paspebiac has a frontage at the shore line of 6,800 feet and projects 4,800 feet seawards therefrom. They are of particular interest in being unusually outstanding examples of the results of changes which may occur in the prevailing direction of currents on a coast line, and in the studies of the adaptation of works to the formation or maintenance of harbours where like conditions are encountered; a very similar set of conditions accounts for the formation of Point Pelee, on the north shore of Lake Erie.



FIG. 6.—Barachois at Paspebiac, Que.

Of another type is the bar, or island which has formed from the action of currents on eroded material from the Scarboro bluffs, and which forms the sheltered area known as Toronto Harbour. (Fig. 7.)

The location of harbours at the mouths of rivers on a coast line such as the above is logical as not to necessitate demonstration, and will be found to apply generally not only on the Atlantic Coast, the Gulf and River St. Lawrence, but on the Great Lakes, the interior lakes, and on the Pacific Coast. Where advantage is offered by nature of an embayment in the coast



FIG. 7.—Harbour at Toronto, Ont.
(Heavy lines indicate work done by Public Works Department)

line, particularly if a jutting headland offers shelter against the prevailing or heaviest storms advantage of such will be taken in the location of a harbour, although it may necessitate the construction of additional artificial shelter works in the form of breakwaters.

With the development of the territory adjacent to or dependent on the harbour and the increase in movement of goods, it has been the experience that accommodation becomes necessary for larger and deeper draft vessels in both harbour area and wharfage facilities. If the local situation permits, this is provided within the sheltered area at the mouth of the river, or that provided by any natural feature. It is often found that the requirements of the traffic cannot be met within the limits of these naturally sheltered anchorages and artificial means must be adopted to provide the additional and deep water area.

A most valuable contribution to the engineering literature on the design of exposed structures is "Wave action in relation to engineering structures," by the late Capt. D. D. Gaillard, published as Professional paper No. 31 of the Corps of Engineers, U.S. Army.

Other generally used types are of timber-crib, stone ballasted type, which may be protected against teredo or limnoria action in sea water by creosote process; this type is used where the breakwater is to be used also as a landing wharf. Reinforced concrete cribs have been used successfully, the earliest of the type constructed in Canada being at Goderich on Lake Huron, built in 1912, under Col. H. J. Lamb, M.E.I.C., as District Engineer. Stable foundation conditions are necessary where that type is used, an advantage of the timber-crib or of the rubble mound types being the flexibility which allows them to adjust, with minimum subsequent repair expense, to an unstable foundation.

The most noticeable difference between types of most harbour works on the East Coast, the Great Lakes and interior lakes or waters, and those used on the Pacific Coast arises from the absence of ice forming winter conditions on the Pacific whereas such conditions prevail in the East, and also from the generally greater degree of shelter available at the sites of harbours or landings on the Pacific Coast. There, structures are predominantly of timber pile construction, which, due to the economic accessibility of that material, absence of ice conditions, and a fair degree of shelter, the type is successfully used. Protection against the ravages of the teredo must be given by creosoting the timber, which otherwise would be destroyed in less than six months.

Dredging and Dredging Plant

References made in this paper to the increases in size of ships and of greater depth they required necessitate some mention of dredging and of dredging plant. The earliest dredge of which mention is made is a steam

dredge, acquired under the Union, for \$6,000, and used in the improvement of Montreal Harbour and the Ship Channel. In 1892 the Ship Channel fleet consisted of—

Four elevator dredges,	One store ship,
Five tugs,	One sounding scow,
Three stone lifters,	Two flat scows,
Twelve dump scows of 80 cubic yards capacity,	Two coal barges.
Two dump scows of 150 cubic yards capacity,	

At the commencement of the Great War the Department had acquired floating plant of a value of approximately five million dollars, distributed for use on the Atlantic and Pacific coasts, the Great Lakes, and the interior lakes of the Prairie Provinces and British Columbia.

This plant, supplemented by the use of privately owned plant used on works awarded by tenders had brought about a large degree of betterment in channels and harbours. All modern types of dredges, rock breakers, tugs, scows, etc. were included. The necessity for retrenchment in expenditures coinciding with the advanced state of the improvements effected permitted and warranted the disposal of the major part of the fleet, and since then the Department has maintained the more generally useful and adaptable units, and has carried out a large part of the dredging needed, by contract, after public competition.

In this way the Department by keeping accurate record of cost of operation of its own plant is in a position to prevent inflation of prices by private owners of plant; if necessity arises unexpectedly for dredging to be done the Departmental plant can be diverted thereto without delay; if need arises for curtailment of expenditure the plant of the Department can be shut down, whereas on contract work the Department is bound to fulfil the terms of the contract. A further circumstance is that on contracts involving large quantities and extending over considerable time the contract rate cannot be altered to take advantage of any reduction in operating costs. Such reductions would be reflected in costs of Departmental plant operations; increases in costs, if of any moment may result in claims for compensation from contractors.

Pioneer

The development of Canada would present a vastly different picture if it lacked the adventurous, pioneering spirit which has characterized the peoples who have sought its shores. As they penetrated farther and farther into the interior to develop the country's resources, earn a livelihood and establish homes, settlements and industries, their first means of transportation was by the waterways. As development continues, roads and railroads are built to provide safer and swifter transport, and the waterways become

less used. The economy of water transport remains a factor available for use as development proceeds, and to supplement other man-made means of communication and transport.

The present mining development in Northern Quebec, tributary to the Harricana river, is cited as an illustration. Rising north of the height of land and flowing north to James Bay the resources of timber or of the agricultural areas on its watershed were not economically exploitable. The construction of the National Transcontinental Railway, crossing as it does the rivers of the northerly slope of that area, provided a means of transport to market of the lumber, and of the produce of farms. The supplies of machinery for saw mills, and for lumber camps had to be handled by the river and in 1919 a small dredge was assembled at Amos, where the river and railroad meet, for use in improving the main and branch channels of the river, which until then was not usable for craft of over $3\frac{1}{2}'$, and only for a distance of about 4 miles above Amos. Almost coincident with the exploitation of the lumber resources the prospector for minerals arrived and the development of the gold resources of the region has steadily forged ahead. From the original development work on the Siscoe mine in 1920, there are now eleven plants in full operation handling from 100 to 600 tons of ore per day. Instead of the work needed for the conduct of lumbering operations being completed and work then ceasing, the improvements have had to be steadily prosecuted, the channels maintained and improvements carried farther afield as more properties were proved up. As communities developed wharves have been built and enlarged, the capacity of many being already overtaxed.

These communities requiring speedier transportation, or to be linked with the waterway, the Provincial Government has constructed highways, and also as development demanded, railways were added, the Nipissing Central being built in 1928, and the Canadian National has now under construction a branch line from Senneterre through Val d'Or to Rouyn. The growth of the district and of the water-borne traffic may be briefly summarized.

- 1920—Approximately 12,000,000 ft. B.M. spruce and jack pine in round logs towed down the river by steamers and about 200 tons of mining and lumbermen's supplies.
- 1925—Approximately 8,000,000 ft. B.M. and 1,500 tons of mining machinery and supplies.
- 1930—Approximately 2,000,000 ft. B.M. and 4,000 tons of machinery and supplies.
- 1933—Approximately 1,500,000 ft. B.M. and 8,500 tons of machinery and supplies.
- 1934—Approximately 1,000,000 ft. B.M. and 50,000 tons of machinery and supplies.
- 1935—Approximately 600,000 ft. B.M. and 85,000 tons of machinery and supplies.
- 1936—Approximately 350,000 ft. B.M. and 180,000 tons of machinery and supplies (including gasoline).

At what stage in the development the roads and railways will supplant the waterway, and when the waterway will again become the economical means of transport and to what extent, is wholly a matter of conjecture. The future of the region seems assured for many years to come, and the wisdom of the expenditure to aid the pioneers and their successors is amply demonstrated.

In the Maritime Provinces, the accessibility of the sea coast has rendered services of this nature largely unnecessary, but the Saint John River and its large tributaries, and the Miramichi River, both in New Brunswick, are cases in point. The "Dawson" route from Lake Superior to the Red River, elsewhere dealt with, the Yamaska, the St. Francis, the Lievre and the larger tributaries of Lake St. John in Quebec, the Trent, the Grand and the Thames rivers in old Ontario, and in later years the Red, the Hole and the Echimamish Rivers in Manitoba, the Saskatchewan, the Montreal, the Cumberland, the Beaver and the Meadow Rivers in Saskatchewan, the Lesser Slave and the Peace in Alberta, and the Columbia, the Fraser, the Stikine, the Finlay, in British Columbia, together with the Yukon River, among many, form interesting examples of the varied uses of the waterways in facilitating the pioneering efforts of Canadians, and of the diversity of public works used to ease and otherwise assist them, such as dams, training works, lining cables, removal of boulders and snags, and dredging.

Bridges

Mention has been made in the earlier part of this paper of the activities of the provinces of Canada in the construction of roads, and arising out of these works and out of the canal construction of concurrent time the present policy of the Dominion in respect to the construction of highway bridges has developed.

Following the construction, in 1837, of the canal through Burlington Beach into Burlington Bay, a ferry was maintained by the United Provinces, and continued under the Dominion, to be succeeded by a bridge as highway, and street railway traffic increased. Tolls were collected for many years, but have not been exacted for some time.

The Ordnance Canal route up the Ottawa, to the Rideau, and thence via the Rideau and Cataraqui to Kingston on Lake Ontario, constructed for defence purposes by the British Government, was supplemented by a highway from the Quebec side of the Ottawa to Bytown (now Ottawa), and a bridge was erected across the Ottawa river at the site of the Union bridges, below the Chaudiere. The Ottawa city bridges, maintained by the Department, include the Laurier bridge over the Rideau Canal and C.N.R. tracks (rebuilt 1901), and the Connaught Plaza, built in 1912 to replace the old Dufferin and Sappers bridges crossing the canal at Sparks and Wellington Streets.

Incidentally, Colonel By, R.E., who built the Rideau Canal, succeeded in bridging the turbulent Chaudiere Channel between Upper and Lower

Canada in 1837, with an arch bridge, successively replaced by a suspension bridge in 1843, a pin-connected truss bridge in 1899, and a riveted truss bridge in 1919; a very good example of bridge design progress in Canada, to meet increasing traffic demands across the Ottawa during the past century.

When reconstruction of the Union bridge was necessary in 1919, the cost was borne share and share alike by the Dominion and the two provinces of Quebec and Ontario, subsequent upkeep being assumed by the Dominion. The bridges at Bryson (1886); Portage du Fort (1901 and 1904); Chapeau (1876 and 1912); Des Joachims (1886); and North Timiskaming (1919), on the Ottawa River were constructed at Dominion expense, as a liability connected with the Ottawa River slides and booms and storage works, and as a contribution towards the development of the district.



FIG. 8.—Bow River Bridge, Banff, Alta.

The original Intercolonial railway bridge over the Restigouche River, the boundary between Quebec and New Brunswick, having become too light for the heavier rolling stock required by rail traffic, the Dominion assumed the bridge, and has maintained it for highway traffic.

A bridge over the Assiniboine River near the boundary between Manitoba and Saskatchewan, near Shellmouth, Man., was built and is maintained by the Department. Several bridges were also built in the Northwest Territories, at Battleford; at Calgary (1897); MacLeod (1897); Edmonton (1899), and the Banff, Alta., bridge was rebuilt (1920). (Fig. 8.)

The Hawkesbury, Ont.-Grenville, Que., bridge over the Ottawa River was built in 1930 under the policy which has been adopted of constructing bridges, where warranted, over Interprovincial waterways, when the adjoining provinces will absorb equal shares of the cost with the Dominion;

subsequent maintenance, not including replacement, being borne chiefly by the Dominion. This does not apply to bridges wholly within a province, the cost in such cases being considered as the affair of the province.

Bridges over streams forming part of the International boundary are in a different category, and the policy is to construct such bridges as are considered warranted, for highway traffic, in conjunction with the appropriate authority in the United States, each bearing one half of the first cost and subsequent maintenance. The bridges at Edmundston, Clairs, and St. Leonards, over the Saint John River, and that at Vanceboro over the St. Croix River, boundary streams between New Brunswick and Maine, are of this category.



FIG. 9.—Lift Bridge, Selkirk, Man.

The LaSalle Causeway and bridges, over the outlet of the Cataragui River at Kingston, Ontario, arise out of the main provincial highway constructed by the Provinces of Canada prior to Confederation, and in this case over a reach of the Rideau Canal, a continuing liability of the Dominion.

The construction program of the Dominion undertaken for the relief of unemployment, during the recent depression, provided funds for the construction of highway bridges over the Red River at Selkirk, Man. (Fig. 9); over the South Saskatchewan River at Outlook, and over the North Saskatchewan at Borden,¹ in Saskatchewan. These, being within their boundaries, will be turned over to the province on completion.

¹The design and construction of this bridge are described in another paper by Messrs. C. J. Mackenzie, M.E.I.C., Dean of Engineering, University of Saskatchewan, and B. A. Evans, Senior Assistant Engineer for the Department of Public Works of Canada. *The Engineering Journal*, May and October, 1937.

Aviation

The development of aviation in Canada has been under the supervision of the Department of National Defence in both its military and civil aspects. That Department however enlisted the aid of the engineering services of the Public Works Department in the development of the landing field, at St. Hubert, P.Q., and at that field in the provision of mooring facilities for the ill-fated dirigible R-100.

The St. Hubert Airship mooring tower has been fully described in the paper presented by R. deB. Corriveau, M.E.I.C., Assistant Chief Engineer, to be found in the Engineering Journal of April, 1930.

The International Waterways Commission

It was only natural to expect that out of the increasing uses made by citizens of both countries of the Great Lakes and other boundary waters, questions would arise which had in them the germ of possible international friction. To deal with such matters the International Waterways Commission was organized in 1905, composed of representatives of the Canadian and United States Governments, and accomplished highly important work in ascertaining a basis of settlement for a number of vexed questions affecting the boundary waters. It proceeded also to delimit the boundary line along the St. Lawrence from its intersection with the 45th parallel at St. Regis, through the Great Lakes and connecting rivers to the Pigeon River.¹

Through the Commission negotiations with Washington were carried on which eventually resulted in that admirable expression of the good feelings between Canada and the United States, The Boundary Waters Treaty, of 1911.

Louis Coste, who had been Chief Engineer of the Department was a member of the Commission, and it functioned under the aegis of the Minister of Public Works.

The Dry Docks Subsidies Act

Mention is made earlier in this paper of the construction of the Lorne dry dock, at Levis, Que., in 1888, and the dry dock at Esquimalt, B.C., in 1887. Running through the reports from year to year of the Public Works Department are descriptions of governmental activities to safeguard ships against possible accident. Lighthouses to guide vessels are the initial step, followed by the subsidizing of tug boats to guide and often to rescue vessels in distress, and the installation of a telegraph line along the shore by which the progress of vessels could be reported to their ports of destination. But despite the provision of the best possible aids to navigation, ships cannot completely avoid trouble, and charges for insurance against loss of ship or cargo are a material factor in the cost of transportation.

¹Report of the International Waterways Commission sessional paper No. 19a, 1913.

Since it seems inevitable that damage to ships will occur provision must be made of repair facilities, the most costly being dry docks, either of the graving or the floating type, and without which repairs would not be possible to the most vulnerable part of ships, their hulls. For the smaller classes of vessels, up to about 3,000 tons marine railways are provided, but above about that limit recourse must be had to dry docks.

To supplement the lighthouses, buoys, and other aids to navigation, and channel improvements, and as a further means of keeping down insurance rates the government built the Lorne and Esquimalt dry docks, above mentioned. These were adequate to receive ships of the sizes they could accommodate, 25 feet in draft and up to 500 feet in length.

On the Atlantic Coast of Canada there was no corresponding facility, and to meet the situation the Halifax Graving Dock Co. Ltd. was subsidized by the Canadian Parliament under 45 Victoria, Chapter 17. The British Government assisted by subsidy in the construction in order to have a repair base for the North Atlantic Squadron, and financial assistance was given by the city of Halifax. The Halifax Dock was built in 1886-1889.

As the first decade of this century brought increasing trade through the St. Lawrence route with correspondingly larger ships, and as there was indication of expansion of a ship building industry in Canada the Government, to aid both the shipping and the shipbuilding industries enacted the Dry Docks Subsidies Act. Under its terms private companies could secure, on a favourable report by the Minister of Public Works as to the need of the facility, a guarantee of reimbursement of the cost of construction of graving or of floating dry docks with ship repair facilities, the Act setting out the minimum dimensions and capacities the subsidized structures are required to have.

Under the provisions of the Act dry docks were subsidized, as follows:

Year Completed	Place	Type	Dimensions
1904	Collingwood, Ontario.. . . .	¹ Graving	526·15 feet by 59·8 feet by 14·8 feet
1910	Collingwood, Ontario.. . . .	² Graving	413·2 feet by 95 feet by 19·2 feet
1910	Port Arthur, Ontario.. . . .	Graving	723·4 feet by 77·6 feet by 16·2 feet
1912	Montreal, P.Q., Fig. 10.. . . .	Floating	601 feet by 100 feet by 32·6 feet
		Class II	
1915	Prince Rupert, B.C..	Floating	600 feet by 103 feet by 32 feet
		Class II	
1923	¹ Saint John, N.B., Fig. 11.. . . .	Graving	1,164·6 feet by 131 feet by 40·3 feet
		Class I	
1925	Vancouver, B.C..	Floating	556·6 feet by 104 feet by 28 feet.
		Class II	

¹The Saint John, N.B. Dry Dock; by E. G. Cameron, the Engineering Journal, October, 1923.



FIG. 10.—Duke of Connaught Floating Drydock, Montreal, Que.



FIG. 11.—Drydock, Saint John, N.B.
(H.M.S. Norfolk in dock.)

To meet the need of adequate drydocking facilities for the larger ships on the St. Lawrence, the Government constructed the "Champlain" dry dock, at Levis, Que., work being commenced in 1911 and the dock taken over from the Contractors in 1921.¹ The need of larger facilities than those already existing on the Pacific Coast was met by the construction of the New Esquimalt dry dock, at Esquimalt, B.C., in 1920-26, by the Department.² It is 1,150 feet long, 125 feet clear width at entrance, and carries 40 feet over the entrance sill at high water.

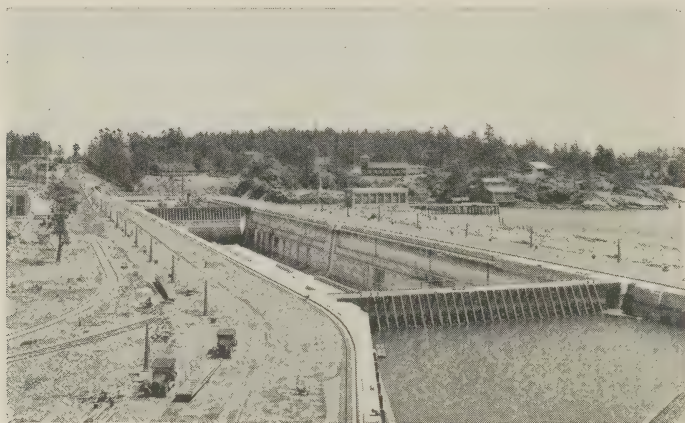


FIG. 12.—New Drydock at Esquimalt, B.C.

The Navigable Waters Protection Act

From earliest times man has made use of the facility provided by waterways in his business affairs, and the reservation of this right of common user to the public descends to us in the Common Law of England. It is so recognized, and would give place only to the necessities of public health and sanitation, as expressed in the Boundary Waters Treaty of 1911 with the United States.

That this right was of common and equal interest to all the people was recognized in the B.N.A. Act, which conferred exclusive authority on the Parliament of Canada to legislate respecting "navigation and shipping", under Section 91, Enumeration 10 of that Act. While authority was thus vested in it to do so, Parliament did not enact legislation to protect the public against damage or obstruction to the navigable waterways until the Session of 1886, when it passed the Navigable Waters Protection Act, (Ch. 36, 4th Session, 5th Parliament). This arose from the need of checking the indiscriminate and harmful practice then in vogue of dumping the refuse from saw mills into streams and lakes. As the use of waterways by com-

¹The Champlain Dry Dock, *Engineering News*, December 18, 1913.

²The Champlain Dry Dock for Quebec Harbour; by U. Valiquet, M.E.I.C., *Trans. Can. Soc. C.E.* 1918.

³The New Esquimalt Dry Dock; by J. P. Forde, M.E.I.C., the *Engineering Journal*, December, 1925.

merce extended, and industry developed the need of wharves or piers, of bridges, or telegraph or telephone or power lines or other works which might affect the use of the waterway by commerce, the scope of the Act was extended. As now enacted, Ch. 140, R.S.C., 1927, any work is unlawful if constructed in, over, under or through a navigable body of water in Canada if the approval of the Governor General in Council is not obtained prior to construction, and if a work, not so approved, is considered by the Governor in Council to be an obstruction to navigation he may order its removal at the expense of the owner. While the Act does not make mandatory the obtaining of approval, lack of such creates a "cloud" on the title to the structure, in that if any party suffers injury from its presence, the owner's defence against any action which may be brought may be materially affected. The Act applies to works of any private individual or corporation, or municipality or provincial government. It does not apply to bridges over the St. Lawrence River, and for those structures special Dominion legislation is individually required.

Part I of the Act, which relates to works in navigable waters, is administered by the Department of Public Works, while Part II, relating to the depositing of materials in navigable waters is administered by the Department of Transport.

Precise Levelling

In the course of the development, in its several stages, of the deep water channel of the St. Lawrence River to Montreal, from the original natural depth of 12 feet to the present depth of 35 feet, at low water, it became increasingly important that accurate knowledge be available of the true level of the sloping surface of the river in relation to the unvarying mean level of the sea from and to which ships and commerce proceeded. In the light of present day practice it may seem a crude method, but the testing of the 20 foot depth in the improved channel was carried out by lashing a spar vertically against the side of a ship, the bottom end of the spar being at the designed depth below the water surface, and the ship with the inspecting party aboard proceeded through the channel to observe whether or not the spar touched bottom.

To secure this basic information "precise or geodetic" levelling was inaugurated in Canada in September 1883, by R. Steckel, C.E., on the banks of the Richelieu River at St. Johns, with an immediate view of determining the surface declivity of the Richelieu and the St. Lawrence above the mean level of the sea during high and low stages of the river, and ultimately the establishment of a standard datum plane of reference on the sea coast and inland waters.

The first precise levelling was that section of the Richelieu between St. Johns and Rouse's Point on Lake Champlain, N.Y. and the datum assumed at a height of 100 feet above the 0 of the American Engineer Corps at Fort Montgomery.

The first few seasons' work embraced the whole Richelieu River from Lake Champlain to the St. Lawrence at Sorel. The first permanent metallic bench mark, BCM (a horizontal chisel line across the end of a copper bolt) was set in the stone foundation of Geo. Nolan's brick residence, west side of the post road, St. Johns, and after more than 50 years this mark is still available and reliable.

The second work done was a line between Montreal and Quebec along the south shore of the river. It was started in 1885 and completed in 1888. The total length of time spent in the field was about 14 months.

It was decided by the Department that work be pushed along from Quebec towards the Atlantic Coast, and westwardly to the Great Lakes. Below Quebec the work would be of great service almost immediately in connection with the proposed determination of the low water plane to which soundings could be reduced in the Beaujeu Channel, previous to engaging in expensive sounding operations, and also the correct determination of mean sea level at some point in the Gulf, free from influence of the discharge waters of the St. Lawrence.

Seasons were spent in establishing flood levels between Lachine and Quebec. Tide stations were maintained between Levis and Champlain and one far down in the Gulf at Riviere aux Renards (Fox River). Now this place was selected because it is approximately within the same latitude as Brest, France, where it so happened similar tide work was being done.

In 1889, J. L. Sanguet, Paris, invented a high precision levelling instrument suitable for this work, but according to Mr. Steckel's theories it could be improved and he offered his suggestions. Not only were these suggestions acknowledged and accepted, to this day they have not been bettered, but two instruments were built embodying them. So around 1901 then the self-reducing Sanguet tacheometers were introduced.

Levelling continued along the beach of the south shore of the Gulf to some 25 miles beyond Father Point, where the right-of-way of the Inter-colonial Railway was used for the first time. By 1903 after 20 years, the total length of line levelled, including cross sections, was 637 statute miles, and the number of metallic and other permanent bench marks established, 261 (CCLXI).

In 1904 the precise party were called to undertake similar work in connection with the extensive surveys undertaken by the Department in the projected ship canal from the Georgian Bay in Lake Huron through the valleys of the French and Ottawa Rivers down to Montreal. This special levelling was performed with the Sanguet instrument without changing in any particular the method finally adopted for precision levelling. This work was important and had to be pushed as rapidly as possible, so not much, if any attention could be paid to the severity of weather, or other uncontrollable sources of error. It was completed in 1906, some interesting and remarkable work was done, and the mileage was 889.

In 1907 the levelling reached Halifax where connection was made with the bench mark used by the Tidal Division of the Hydrographic Service in establishing mean sea level. This survey had maintained a registering gauge for over nine years of successive hours, day and night without a break. Mean sea level at Halifax is now datum to which all records are reduced. The main base line between Halifax and Father Point, across almost three Provinces, and nearly 500 miles long, turned out to be of great accuracy.

With the completion of the main line, work was gradually and systematically extended during the few suitable available months each year. Work generally was requested and no attempt was made to build up mileage. The Lower Provinces offered a great field for checking accuracy at the various harbours and ports in establishing L.W. datum for charts and design of harbour works, and dredging. In Nova Scotia and New Brunswick about 1,000 miles of levelling was done.

In Quebec a large loop line some 450 miles long was run, starting at Matapedia and following the shore of Baie des Chaleurs, across Gaspé Harbour, thence over the route (now the new highway) to Fox River and along the northwest shore of the Gulf to Father Point. In central Quebec there is a good net, and the Montreal-Quebec still remains standard for charts. Including cross sections and spur lines some 2,100 miles has been done.

In Ontario the main line follows the upper St. Lawrence to Lake Ontario. (At Trenton a special line was run in 1908 over the route of the Trent Canal), from Toronto to the Welland Canal and across Niagara to Lake Erie, thence along the shore line to Windsor, finally to Sarnia and Point Edward, including the Georgian Bay work, over 1,900 miles.

In Manitoba the work requested started at Stephen, Minn., and reached the boundary at Emerson, continuing to Lake Winnipeg. We reciprocated in being a good neighbour by establishing bench marks in United States territory.

Between 1883 and 1930 the total mileage amounts to 5,500 miles.

It may not be out of place that tribute be paid to the two engineers principally concerned with this work, both of whom became members of The Canadian Society of Civil Engineers in 1887. To Mr. R. Steckel who, first inaugurated, and for 20 years actively engaged in it, and his immediate successor Mr. C. F. X. Chaloner who, first as Assistant, later in charge, spent 45 years, a lifetime, at it.

This determination having accomplished the object of relating to mean sea level the elevations of permanent bench marks from which to establish the true height of the surface of the majority of Canada's navigable waterways and harbours, the activities of the Department were discontinued, and the records transferred to and incorporated with those of the Geodetic Survey of Canada.

Testing Laboratory

From the inception of harbour development in Canada the natural resources of the country in timber have been depended on as the most generally used construction material. While this is still the case, because of timber being so generally available, and obtainable at economically competitive prices, other materials, and processes are found necessary. Principal among these is portland cement, others being reinforcing steel, concrete aggregates, paints, and in fact the whole gamut of materials on the market for use in the construction industry.

The present Testing Laboratory of the Department was inaugurated in 1892, as a cement testing laboratory, and continued until 1911 testing portland cement exclusively, when the activities were extended to testing gravels, crushed stone, reinforcing steel, and brick. Towards the close of the Great War, and coincident with the reconstruction of the Parliament building at Ottawa, the field of usefulness was greatly extended, so that it now covers all classes of materials used in building construction, as well as processes, and of goods purchased for Government use.

The experience gained in the testing and examination of these goods and materials has been incorporated in specifications under which these are purchased for Departmental use. A further development of great promise has been to co-relate field and laboratory tests and studies of foundation materials and conditions.

Engineering Staffs

To the late George Fred Baillargé, M. Can. Soc. C.E., we are indebted for his painstaking compilation of Engineers and their Assistants employed in Public Works, Canada, from 1779 to 1890, and published as Appendix No. 19 to the report of 1889. Mr. Baillargé's service covered the period from 1844 to 1890, and during the last eleven years as Deputy Minister of the Department. His indefatigable efforts are reflected in the many records he compiled of activities associated with his work, and which were published as appendix to the several annual reports of the Department.

The early engineers were from the Corps of Royal Engineers, since the country was still under Colonial management, and the major engineering matters had to do with canals, in which the element of defence against attack was then, and continued for many years a dominant one.

Col. Cother Mann is the earliest engineer he records; he appears to have made, in 1797, a survey of a proposed canal at Sault Ste. Marie, in Canadian territory, the survey being for McTavish, Frobisher and Co., on behalf of the North West Company. This was the first "Soo" lock, and was built prior to 1803.

Among other technical officers are Admiral Henry W. Bayfield, R.N., under whose direction the coasts of Canada and those of the Great Lakes were surveyed and charted, between 1817 and 1860; Thomas Burnett who

carried out, in 1820, the surveys for the projected Lachine Canal; Capt. Jebb, R.E., who surveyed the route of the Rideau Canal in 1815 to 1817; and Lt.-Col. C. S. Gzowski, who was in the Government service in 1842, and later became president of the Canadian Society of Civil Engineers.

In the Government service at Confederation he records:—

Capt. C. L. Armstrong	J. B. Lepage
G. F. Baillargé	C. M. McCarthy
J. E. Boyd	Alex. McNab
G. P. Brophy	Horace Merrill
Simon Dawson	C. E. Michaud
Pierre Gauvreau	E. G. Milledge
F. N. Gisborne, MICE, FRSC.	Thomas Munro
H. A. Gray	A. G. Nish
Thomas Guerin	J. B. Normand
F. M. Hamel	John Page
Jean Lefebvre	A. Painchaud
E. H. Parent	G. W. Ranney
Jas. Rosa	J. Le B. Ross
Jas. H. Rowan	Thos. S. Rubidge
E. P. Rubidge	David Scott
L. J. R. Steckel	H. R. Symmes.
J. G. Sippel	

Messrs. G. F. Baillargé, G. P. Brophy, Simon Dawson, H. A. Gray, F. M. Hamel, J. B. Lepage, C. M. McCarthy, C. E. Michaud, E. G. Milledge, Jas. Rosa, J. Le B. Ross, David Scott, and L. J. R. Steckel, were still in the Engineering Service of the Government in 1887, when the Canadian Society of Civil Engineers was formed.

Considering the available means of transportation in 1867, John Page must have spent a busy year in his position of Chief Engineer, as he reported on, Supply of water to the Lachine Canal; improvements to the Cornwall Canal; leases of water power to the Welland Canal Co.; project for the Murray Canal; St. Peter's Canal, C.B., construction; River St. Lawrence Ship Channel through Lake St. Peter; proposed water power development by a company at the Lachine Rapids, in the St. Lawrence; water power at the Chaudiere Falls, Ottawa; lighthouses proposed at Cape Tormentine and Cape Jourmain, New Brunswick; projected asylum harbour at Cow Bay (Morien), Cape Breton; Bathurst, N.B., harbour; Neil's Harbour, Cape Breton; Amherst and House Harbours, Magdalen Islands; Herring Cove Harbour, New Brunswick; St. Croix River, N.B., proposed channel improvement; Mabou Harbour, Cape Breton, improvement of entrance; Richibucto Harbour, N.B., proposed improvements.

He had to make his own examinations, as the other government engineers were responsible for the canals, the slides and booms, roads and bridges, and public buildings, apparently only Messrs. Milledge and McNab in the Maritime Provinces, G. F. Baillargé and Pierre Gauvreau in Quebec, and H. A. Gray having to do with harbour works on the extensive coast line of the new Dominion.

In British Columbia, as there was then no direct communication with the East, Hon. J. W. Trutch, C.E. looked after all government activities associated in any way with Public Works. For a considerable number of years harbour works increased in number and extent at a moderate rate, and supervision was mainly centralized in Ottawa.

The increase in size and number of these works and in the extent of territory covered required a degree of decentralization for their proper supervision and efficient administration. Thus district offices were opened in Halifax for the province of Nova Scotia; in Saint John for the provinces of New Brunswick and Prince Edward Island; in Quebec city for the province east thereof; and in Toronto for the province of Ontario, and the West, except British Columbia, in which the district office was continued at New Westminster.

With the growth in development and the general feeling which ushered in the present century the engineering activities and staff expanded to the extent that some 36 districts had been established, with the staffs in proportion. The realignment of effort consequent on the last Great War necessarily imposed on Public Works, as on other governmental activities, a curtailment of effort, and this was incorporated in a reorganization under which the districts were consolidated to sixteen in number, and with a reduction in staffs to correspond.

In view of the manifold and diversified activities of the Public Works Department throughout the Dominion, including not only the nine provinces but the Northwest Territories and the Yukon, the basic scheme of decentralized administration has been found the most suitable and effective, as it permits a close contact being kept not only with the works but with the trend of business in the country, and permits of that degree of flexibility necessary to meet conditions as they change with progress and development throughout the Dominion.

Samuel Keefer was the first Engineer of Public Works of Canada. Born at Thorold, Ontario, January 22, 1811, he was Secretary and Assistant Engineer of Public Works of Canada, 1833-41, becoming Chief Engineer on August 17, 1841, which office he held until 1852. He was the second president of the Can. Soc. C.E.

John Page, senior, succeeded as Engineer of Public Works on November 5, 1853, and continued in the capacity of Engineer of Public Works after Confederation. He stayed with the Canals, becoming the first Engineer of Canals when the separate Department of Railways and Canals was formed in 1879.

Henry F. Perley, who had served his apprenticeship on the engineering staff of the Government of New Brunswick which he joined in February, 1848, with that of the Nova Scotia Government from 1863 to 1865, then as Superintending Engineer of New Brunswick Railways from 1870 to 1872, as Superintending Engineer of Public Works for the Maritime Provinces from May, 1872, succeeded John Page in 1880, and held office until 1890.

He was the first Chief Engineer of Public Works, that title being created and conferred on him by Order in Council of November 25, 1880. He was vice-president, 1887-89 of the Canadian Society of Civil Engineers.

Louis Coste, M. Can. Soc. C.E., who had been an engineer on Public Works from 1884, succeeded Henry F. Perley, and was in turn succeeded by Eugene D. Lafleur, in 1899.

Mr. Lafleur, who died in harness in 1922, after continuous service since September 27, 1881, had seen major developments under the Department initiated and carried out, including the construction of the Champlain Dry Dock at Levis, the deep water wharf on the River St. Charles at Quebec, the Ocean terminals and the dry dock at Saint John, N.B., the Georgian Bay Canal Survey, the development of Port Arthur and Fort William, and of Vancouver and Victoria, in British Columbia.

His successor, Arthur St. Laurent, past president E.I.C., had joined the public service with the Department in 1885, and by his sound judgment and wise counsel, had gained the respect, esteem and affection of all, and it was a distinct loss to the public service that he lived but a short while, until 1923, to give to his country's services a continuance of his courageous intellectual attainments.

The writer, then occupying the position of Assistant Chief Engineer succeeded Arthur St. Laurent.

Government Telegraphs

The Government Telegraph and cable lines, which have been under the control of the Public Works Department since their being incorporated into a unit of the public service in 1879, have played an important part in Canada's development since that time.

Following the construction of a telegraph line which was to connect Halifax with the trans-Atlantic cable terminal at Canso, telegraph and cable lines soon began to function as aids to fishing and navigation along the coast of the Gulf of St. Lawrence and the Bay of Fundy and in addition submarine cables were laid to such important fishing centres as the Magdalen Islands, Anticosti, and Grand Manan Islands.

Well in advance of the construction of the Canadian Pacific, the Government lines passed beyond Winnipeg and extended out over the Saskatchewan and Alberta prairies and, upon the incorporation of British Columbia into the Dominion, this Department took over the privately owned land and cable lines then in operation in this new province.

From this small beginning, there has developed in the intervening fifty years the present Government Telegraph Service, with its ten thousand miles of land line, serving many of the important agricultural, timber, fishing and mining areas in eight provinces and the Yukon Territory.

A factor which contributed to the early development of the telegraph service along the Gaspé coast was the necessity of counteracting Norwegian

competition in the dry cod market. For this reason, the earliest attempt at news broadcasting in Canada was instituted. Daily bulletins were sent over the wire by each office between Matane, on the St. Lawrence side of the Peninsula, and New Carlisle, on the Baie des Chaleurs, reporting:

1. The result of the local fishing on the previous day,
2. The bait supply of the preceding night,
3. The prospect for cod fishing; the state of the weather and the wind of the day up to the moment the bulletin was sent over the wire,
4. The Meteorological Bureau's probabilities and storm warnings.

Each office made manifold copies of these reports, which were prominently displayed and passed out to the fishermen.

Another factor which stimulated the policy of telegraph line construction along the St. Lawrence River and Gulf coast was the need of quick communication between incoming vessels which travelled the Strait of Belle Isle route, and resulted in the building of a line slightly over a thousand miles in length between Quebec and Belle Isle. The distance between Liverpool and Point Amour is less than 2,000 miles and for this reason many vessels were taking advantage of this shorter route.

To stress the many advantages which would accrue from the building of this line, representations were made by the shipping interests to the Department as follows:

"The interests of commerce then, urgently call for the extension of the telegraph line on the North Shore as far as Forteau Bay, or rather to Point Amour (which is east of that bay and where there is a lighthouse and fog-whistle) to meet the requirements of navigation.

"But we shall gain something more by the opening of this line, for when we have a telegraph station at Point Amour lighthouse, which will then be in constant connection with Canada, the United States, and in fact the whole world, it will be possible to land at Forteau Bay, which is easy of access at all times during the season of navigation, despatches, lists of passengers, private messages, etc., etc., after a run of five days only from Moville, Ireland. This would then be the most rapid route for the transmission of news from Europe to America by steamer, and in that respect it would confer an undoubted superiority on Canada. It would be in a sense a realization of the greatly desired five-day journey between Europe and America."

As a result of this pressing need for a means of wire communication, the Department undertook the construction of a telegraph line along the North Shore of the St. Lawrence River and Gulf from Murray Bay to Chateau Bay, Labrador.

The work attending the construction of this line was arduous and slow due to the rugged coast along which it wound its way. It was carried on each season during the period of navigation along the coast, for in the absence of roads of any kind the employment of schooners was necessary for the transportation of poles, wire, provisions, and workmen. It was not, however, until 1901 that the last pole was planted at Chateau Bay, and a submarine cable laid out to the important lighthouse located on Belle Isle.

This line, originally built as an aid to navigation and to speed up news from Europe to America by steamer, has been in operation continuously

since that time, and as the fishing and transportation along the coast increased, this wire service played an increasingly important part in its development.

The early eighties showed much activity in the providing of telegraph lines and cables from the Atlantic to the Pacific.

In the East, cables were laid to the following: Anticosti, Bird Rock, Magdalen Islands, Grand Manan and Campobello Islands.

A telegraph line following the north coast of Cape Breton between North Sydney and Bay St. Lawrence, 126 miles in length, was constructed to connect with an early trans-Atlantic cable, the Magdalen Islands cable, and to provide for the general needs of the fishing industry along that coast.

A short land line was constructed in Newfoundland to provide service between Port aux Basques and the important Cape Ray lighthouse.

On Prince Edward Island this Department, in conjunction with the Anglo-American Cable Company operated a telegraph service which extended the full length of the Island, for the most part along the right of way of the Intercolonial Railway.

New Brunswick received attention in the building of a 42-mile line between Chatham and the Escuminac district and lighthouse.

In Quebec, the quarantine station, which had been for some years in operation on Grosse Isle, a short distance below the city of Quebec, was given wire communication by means of cables and land lines over the Island of Orleans and adjacent islands to the east.

The Chicoutimi area was also served by the construction of a line 100 miles in length from Bay St. Paul, on the St. Lawrence, to the important Saguenay River port.

The bringing of that portion of northern Quebec into close touch with the ancient capital and the enabling of ships which plied the Saguenay River route to communicate with their home ports aided materially in the building up of the Chicoutimi and Lake St. John areas, which now, from an industrial standpoint, enjoy notable prominence.

In the West, with the building of the Canadian Pacific Railway in prospect, the need for wire communication was accentuated, which resulted in the construction of nearly 1,000 miles of telegraph lines on the Prairies up to the year 1885.

The line between Port Arthur and Winnipeg, which had been operated by the Department of Railways and Canals, was transferred to this Department in 1882 and a through line was opened up between Winnipeg and Edmonton by way of Qu'Appelle, at which point contact was made with the new Canadian Pacific wires.

Prince Albert was served by a branch line 100 miles in length which extended north from a station on the Qu'Appelle-Edmonton line, known as Clark's Crossing. This was afterwards extended 14 miles south to Saskatoon. Such places as Touchwood, Battleford, Fort Pitt, Onion Lake and Vermilion, which were scenes of activity during the Riel rebellion, were stations on the Edmonton line.

The following are extracts from the report of the late F. N. Gisborne, the first Superintendent of Telegraphs, who journeyed to Western Canada in the fall of 1883 to supervise the line construction across the Prairies:—

"The land between Qu'Appelle Station and Fort Qu'Appelle (eighteen miles) is good and well adapted for settlement, and the telegraph line has been substantially erected upon the winter trail, which is approximate to the summer route of travel.

"After passing over a well watered and wooded prairie country for twenty-five miles, bad weather overtook us, and during the ensuing night our horses, although hobbled, were stolen. Our District Superintendent's pony was found next evening and a most diligent search was instituted during two subsequent days, both Indians and half-breeds being employed under a promised reward of \$50, if successful in finding them, but without avail, and I was finally necessitated to return to Fort Qu'Appelle to procure another pair of horses (under an agreement to purchase or to hire them pro tem if meanwhile the stolen horses were recovered) I may here state that having given due notice of the theft to the Mounted Police, and having offered the above reward they were finally produced from the hiding place, (where they had been cached in expectation of a higher reward being offered) within a week of my departure and are now in possession of our District Superintendent, who requires them for the service.

"At Saskatoon there were three or four framed buildings awaiting arrival of a raft of lumber from Medicine Hat station on the Canadian Pacific Railway, to complete them. Here we found the scow ferry destined and then en route for Clark's Crossing, and having embarked the three horses and two buckboards we laboured for three hours and were carried three miles downstream before we could effect a landing upon the opposite side of the river.

"At Edmonton a large town has been plotted and the great bulk of lots actually disposed of at prices varying from \$50 to \$800 each, over a space exceeding 1,000 acres, and already over two dozen framed houses and stores have been erected thereupon.

"By general consent and approval the telegraph station has lately been removed from an old and inconvenient room in the Hudson Bay Fort to a new building in a more central situation

"Leaving Edmonton on the morning of the 3rd October, we crossed the North Saskatchewan River by a wire rope ferry and mounted the high and heavily wooded banks opposite the Fort, where the last great massacre of Blackfeet Indians by their enemies the Crees took place, and travelled along side of the telegraph line upon the main trail towards Calgary."

At the conclusion of the Northwest rebellion, two lines were built south of the Canadian Pacific Railway for military purposes: the first provided communication between Calgary and McLeod, serving also the coal mining region of Lethbridge. The second line was constructed for a distance of 90 miles south of Moose Jaw to a station known as the Wood Mountain Post. It is a matter of record that shortly after the massacre of General Custer on the U.S. Western frontier, a great many of the warlike Indians escaped to Canada and settled in the rugged territory between Wood Mountain and the Montana boundary. The building of this latter line was no doubt intended as a precautionary means to forestall any further Indian warfare.

In British Columbia up to 1885, quite an extensive telegraph system had been put into operation. After the original purchase, from the Western Union, of the lines and cables in British Columbia, which represented 430

miles of land lines and 16 knots of cable, the service was extended by new construction and by adding to the lines already in operation. In 1885, the lines in this new western province had a length of 676 miles.

Several sections were built on Vancouver Island, by which Victoria was connected with Cowichan, Somenos, and the coal mines then operating in the vicinity of Nanaimo. On the mainland, the line extended from New Westminster to the north-eastward to Port Moody, Chiliwack, Hope, Yale, Lytton, Ashcroft and Kamloops, which are now well known stations along the railways. From Ashcroft, the line branched off to the north along the old Cariboo trail, serving Clinton, Bridge Creek, Quesnel, Stanley, and the mining town of Barkerville. It will be remembered that Barkerville was the scene of the first important gold rush in British Columbia and it is on record that many millions in gold nuggets were taken from the creeks in that area some years previous.

In October, 1884, a submarine cable was laid between Clover Bay, Vancouver Island and Dungeness, Washington Territory, to connect with the Puget Sound Telephone Company's line to Seattle and with the United States Government line to Cape Flattery. This cable was the means of speeding up wire communication between Victoria, Portland, and San Francisco.

In a report to the Department, the following is noted in connection with the then-existing conditions at the coast:

"The land line between New Westminster and Granville (now Vancouver) has been entirely reconstructed along the new waggon road, the old trail having been abandoned. During the fiscal year 1884-85, there were 76,797 paid messages transmitted over the Government lines in British Columbia, which yielded revenue of \$35,655. This was slightly in excess of total expenditures."

The main line of the C.P.R. having been completed, the activity in the West was largely confined to the centres touching or in close proximity to the railway. Possibly for this reason, telegraph construction up to and between 1885-98 was limited to the following construction on Vancouver Island and the mainland: Victoria to Cape Beal, 115 miles, which followed the southern coast, Port Alberni to Parkesville, 30 miles, Lillooet to Ashcroft, 65 miles.

In the East, some attention was given to cable laying with the result that the following islands were furnished with a means of communication by submarine cable:

Ontario.—The important agricultural area on Pelee Island was connected by cable and land line to Leamington.

Quebec and Maritime Provinces.—Brier Island and Digby Neck were given cable service.

A cable was laid between the coast of Cape Breton and St. Paul's Island, which is located in the main shipping channel 19 miles from the northern part of Cape Breton Island.

A cable was laid between Mingan, on the northern shore of the St. Lawrence, to Anticosti Island to permit direct communication between these two areas.

Communication was established between Shippigan Island and Miscou Island, N.B. by the construction of 23 miles of land line.

Ile aux Coudres, in the St. Lawrence Channel, was connected with Baie St. Paul.

In 1898, the well-remembered newspaper headlines which announced in large type that much gold had been discovered in the Yukon started thousands of miners up the trails from Skagway and Dyea, Alaska, and thence by boat and scow downstream from Lake Bennett to Dawson. This called for quick action in the matter of providing a quick means of communication to these new gold fields.

Upon the arrival of an ample stock of telegraph wire at Lake Bennett, construction was immediately begun and within a year the intervening 565 miles was bridged by this new service, which brought Dawson, with its many thousand gold-seekers, into fairly close touch with the outside. Between Lake Bennett and the port of Skagway the wires of the White Pass Railway were used. From Skagway south, communication was by steamer mail. However, to provide a more speedy and an all-Canadian route to the Yukon's rich gold fields the Government line under the Public Works Department was extended southward to Atlin and two years afterwards this line was extended 885 miles southward by way of Telegraph Creek and Hazelton to tie-in with the line which was then in operation between Quesnel and Ashcroft, B.C. This line was, in 1902, extended 90 miles north of Dawson to the Alaska boundary to connect with the U.S. Army system operating in Alaska.

By this means, the through wire over Canadian territory was placed in service and was a great boon to northern British Columbia and the Yukon. Although the great mining activity has subsided in the Dawson area, the line still functions in a very satisfactory manner, providing for the needs of the explorer, trapper and miner in the extreme northern sections of British Columbia, for the water and air transportation along the Yukon River and for the needs of the dredge operated gold workings still progressing in the creeks tributary to the Klondike.

Between the years 1900 and 1910, increased activity was displayed in providing telegraph lines in various parts of Canada.

The southeast portion of British Columbia was attracting much interest in fruit growing and mining and as a result 400 miles of line were constructed, serving such places as Kamloops, Penticton, Vernon, Kelowna, Sicamous, Golden and Invermere.

On Vancouver Island cables and land lines connected up various islands in the Gulf of Georgia, the most important being the Salt Spring Island group, including Pender, Mayne and Gabriola.

Land lines were extended down the Alberni Canal from Port Alberni to Bamfield. Another line out of Port Alberni was constructed along the west coast as far as Clayoquot, principally to serve the important fishing establishments operating along that coast.

Other lines put into operation connected Nanaimo with Comox, and Courtney with Campbell River.

In the Cariboo district of British Columbia, a telephone line, 62 miles in length, was constructed between 150-Mile House and Quesnel Forks.

Shortly before the construction of the Grand Trunk Pacific Railway to its Pacific Coast terminal, this Department constructed 198 miles of line from Hazelton and along the Skeena river to its mouth, and thence northward to Port Simpson, the first capital of British Columbia.

In Alberta, the Peace River district was being rapidly settled and the lack of telegraph service was keenly felt. A line was built from Athabaska Landing, which had previously been connected with Edmonton, along the south shore of Lesser Slave Lake to Mirror Landing, Grouard, Peace River Crossing, thence in a southwardly direction to Dunvegan and the Grand Prairie country. This line had a length of 421 miles. A second line of 65 miles was put into commission between Edmonton and Alexandria.

In Saskatchewan, the large commercial fishing interests were served by a line which extended northward from Battleford to Ile a la Crosse, a distance of 245 miles.

In the East, the lines in Cape Breton were increased by 500 miles, principally along the coast of that Island.

In Quebec, lines were constructed on both sides of the Saguenay River between Tadoussac and Chicoutimi with an extension northward of 65 miles to Peribonka in the Lake St. John area.

In the Timiskaming section of northwestern Quebec, a line of 125 miles was constructed between the Kipawa and Quinze Dams for use in regulating the flow of water from the upper reaches of the Ottawa River and northern lakes.

The telephone service in the Parliamentary and Departmental Buildings in Ottawa, being under the control of the Public Works, the following might be noted with interest. In 1902, the number of telephones installed in the Government offices numbered 200, whereas in 1937 this number has increased to 2,400.

During the early years of the War, notwithstanding the activities overseas, the Government Telegraph Service extended its communication lines to serve the pioneers in the rapidly developing out-lying points, which, up to that time, had been more or less isolated from the older and more largely populated centres. During the period the following important points were linked up:

On Vancouver Island, Campbell River, which is situated on the Seymour Narrows, was connected with Cape Scott on the extreme westerly tip of the Island. This line is 200 miles in length and was built along the shore,

serving important fishing and lumbering points, as Menzies Bay, Alert Bay and Coal Harbour. This line was at the same time extended southward from Campbell River to Vancouver, crossing the Gulf of Georgia by a series of cables connecting Quadra and Cortez Island to the mainland. Important points, as Powell River, Sechelt, Bowen Island and North Vancouver were thus served.

The Queen Charlotte Islands were given wire communication by the construction of 123 miles of line, linking up Massett, Port Clements and Queen Charlotte City.

On the B.C. mainland, lines were put into service between Vancouver and Squamish, and terminus of the Pacific Great Eastern Railway at the head of Howe Sound.

The station on the Grand Trunk Pacific known as Terrace was connected with the important mining centres of Anyox and Stewart, the latter being situated at the head of Portland Canal.

Much needed wire facilities were furnished that vast region lying to the west of the Cariboo country by the construction of a telegraph-telephone line between 150 mile House on the old Cariboo Road and Bella Coola on the Pacific Coast. This line is 350 miles in length and connects the town of Williams Lake, which is recognized as the metropolis of the Cariboo district, with the vast ranching area in the Chilcotin country.

The now famous Pioneer Mine in the Bridge River area was given telephone service with Lillooet during this period.

Within the last few years, high grade ore having been struck at the Pioneer, Bralorne and other mines in that region, the original line has been replaced by much improved facilities furnishing fast telegraph and telephone communication with Vancouver and other large centres.

In the southern portion of British Columbia, the Government owned lines during this period had reached the Okanagan area, Nelson and Trail, and had penetrated to the coal mining area in East Kootenay.

In Alberta, Fort McMurray, the point of departure for steamers plying the MacKenzie River route, was connected up with Edmonton by the building of a line along the Athabaska River for a distance of 250 miles.

The line which connected Edmonton with the Peace River district was extended from Grand Prairie into the Peace River Block of British Columbia to the present terminus at Hudson Hope, which is but a short distance from the foothills of the Rockies.

In the East, attention was given to cable laying. Two heavily armoured cables were laid across Northumberland Strait to Prince Edward Island; a four-conductor cable was laid between Cape Tormentine and Borden and one containing two conductors was put down between Wood Island and Cariboo Point in the Pictou area. By means of these, telephone service was inaugurated between Prince Edward Island and the provinces of New Brunswick and Nova Scotia.

The cable service in the Grand Manan area of the Bay of Fundy was increased by the laying of cables to the adjacent islands, to the Life Saving Station on Wood Island and the well-known Atlantic Coast lighthouse on Gannet Rock.

The extent to which the Government Telegraph Service had developed up to and including the year 1916 is reflected in the fact that in the above-mentioned year the mileage of the Government lines held second place amongst the telegraph services in Canada. The figures are as follows:

	Land Line	Submarine Cables
Great North Western Telegraph Company	10,064	13
Canadian Pacific Telegraph Company	14,617	95
Government Telegraph Service.	11,516	336
Grand Trunk Pacific Telegraphs.	5,277	1

In the years immediately following the War, the mileage of the Government Telegraph Service reached its highest figures.

During the period, however, from 1925 to 1931, owing to the construction of additional railways in the West and the adoption of a policy of expansion on the part of the British Columbia Telephone Company, certain lines, both telegraph and telephone, having served their purpose as pioneer undertakings, were abandoned or sold.

The original Northwest Territories line from Qu'Appelle to Edmonton, with a length of 500 miles, was abandoned in 1925; also the 102 mile section between Moose Jaw and Gravelbourg.

Coincident with the construction of the Trans-Canada telephone system in 1928-29, the British Columbia Telephone Company, wishing to extend their lines eastward to the Alberta border and develop the telephone field on the southeasterly portion of British Columbia, negotiated with the Department for the sale of its lines in that territory. This purchase was on a rather large scale and brought about the transfer of 1,666 miles of pole line and 3,000 miles of wire to the Telephone Company.

Pursuing the same policy of expansion several years later the British Columbia Telephone Company purchased telephone lines on Vancouver Island from this Department to the extent of 223 miles of poles and 455 miles of wire. These lines extended from Victoria to Sooke, and also the network of wires and cables serving the Gulf Islands, the principal ones being known as the Salt Spring Island group.

During this period other lines in Saskatchewan and Alberta, having served the purpose for which they were constructed, were also abandoned to avoid duplication of telegraph services, the railroads having entered the fields formerly served exclusively by this Department.

These lines, having a total mileage of 275 miles, are as follows. Assiniboine to Wood Mountain, Sask.; North Battleford to Meadow Lake, Sask.; Athabaska to Plamondon, Alta.; also 90 miles of line in the Yukon between Dawson and the Alaska boundary.

While the Department was disposing of non-essential lines in certain sections, new fields requiring telegraph and telephone facilities were not neglected. The policy of the Department was to furnish communication and service to localities urgently requiring same and which could not be served by other agencies. Thus in 1929 an important telegraph line was constructed between the town of Peace River and the thriving frontier settlement of Fort Vermilion, 253 miles to the north. This line passes through the well-peopled Battle River country as far as Key River. From this midway station, a spur line extends eastward to Carcajou Landing on the Peace River, a point of call much used by the steamers plying up and down the Peace River. Extending northward, the line passes through a vast new country, awaiting to absorb the next accelerated movement of land seekers who, with this means of wire communication at their disposal, need not be troubled with the fear of isolation.

In the Cariboo district of British Columbia, the growing railroad town of Prince George was given direct communication with the mining fields in the Barkerville area and other settlements along the old Cariboo road by the construction of a telephone line to the town of Quesnel, which is a distributing point for the many communities and ranches along the Fraser River.

Attention is here directed to the very significant fact that in British Columbia there is no provincial telephone system as is the case in Alberta, Saskatchewan and Manitoba and for this reason the Government Telegraph Service is called upon to provide local telephone service for quite a few of the towns in that province which have not grown to such a size as to attract the attention of commercial telephone organizations. Some of these communities have grown up around the original Government telephone office and are now given local telephone service through switchboards established therein. Some of the larger places enjoying such service are—Ashcroft, Clinton, Lillooet, Lytton, Williams Lake, Burns Lake, Smithers, Vanderhoof, Hazelton and Alert Bay. More than 1,100 telephone subscribers attached to local and rural telephone lines in British Columbia pay the customary charge of \$30 per year for such service and thereby a substantial revenue is secured by this Department.

The recent recurring drought years in southern Alberta and Saskatchewan brought about quite an extensive migration of settlers to the well-watered land in Peace River Block. These newcomers took up farms in many sections of the Block and to provide the villages and hamlets which sprang up with a means of communication this Department was called upon to construct some hundreds of miles of rural telephone lines. The growing towns of Pouce Coupé and Dawson Creek, the latter at the terminus of the Northern Alberta Railway, have been given local and long distance telephone service through the telephone exchange located in each of these centres. This is in addition to a fast telegraph service to all important points between Hudson Hope, in the extreme westerly part of the Block,

and Edmonton. This line is operated as our circuit and has a length of 720 miles. It is a fact that these lines, both telegraph and telephone, are so laid out that there are few, if any, communities in the Peace River Block that are without adequate communication service.

In the East, the major construction work undertaken in recent years was the rebuilding of the western portion of the 40-year old line which follows the North Shore of the St. Lawrence. This was made necessary to provide for the requirements of the pulp and paper industry along the coast. Within the last fifteen years, some of the larger paper interests, taking advantage of the Waterway along the St. Lawrence and the abundance of spruce in the regions to the North, established pulp operations at many places along the coast as far east as Seven Islands. The most important of these are centered at Outardes Falls, Comeau Bay, Franquelin, Godbout, Trinity Bay, Pentecost River, Shelter Bay and Clark City. A new cedar line, carrying two wires, has been completed as far as Seven Islands, a distance of 350 miles, thus assuring these new enterprises adequate wire facilities to handle the increasing volume of telegraph traffic. At Comeau Bay, the erection of a large pulp and paper mill is now in progress, the cost of which may reach eight or ten million dollars.

The laying, in 1930, of the fourth submarine cable across Northumberland Strait to Prince Edward Island was an important addition to the communication service to that Island province. This new installation is the latest type of telephone cable and in addition to providing Prince Edward Island with a means of developing their long distance telephone lines to the utmost degree, carries the Island's radio broadcasting service. By this means, the people living in that province may enjoy to the same degree as those on the Mainland the advantage of the coast-to-coast, trans-Atlantic, or other radio broadcasts.

Except in a few instances in the last ten years, when the Department has built lines into outlying areas, it has been occupied more or less with the increasing of facilities in territories already served in a general way. With the influx of new settlers and the growth of population in certain favoured areas, hundreds of miles of small branch lines have been constructed. New lumbering, fishing and mining centres have been connected up with the wires in their respective localities, without increasing the total mileage of the Government system to any great degree, and space does not permit us to deal with this in detail. The Service as a whole has been and is a very important factor in Canada's upbuilding.

It is difficult to visualize without having made an inspection of this Department's telephone, telegraph lines and cables the extent to which that service enters into the everyday life of the many thousands of Canadians in the regions served by the Government-owned telegraph and telephone system and these are to be found in every province with the exception of

Manitoba. A fisherman on Scatarie Island, the most easterly point of Cape Breton Island, may call Sydney over the telephone, or a boatman at Cape Scott, at the most westerly point on Vancouver Island, may send a telegram to Victoria or Vancouver in quick time. An airplane pilot at Fort Vermilion, Alta., or Fort St. John, may be furnished with weather reports or instructions from Edmonton headquarters within a few minutes. The fishermen along the Labrador coast can ascertain the day and hour the schooner or steamer will arrive to take away his hard earned harvest. The trawlers along the west coast of Vancouver Island keep in daily touch with the trend of the fresh fish market and are furnished with prices and demand information enabling them to market their fish to the best advantage. The grain elevator operated at Grand Prairie can be supplied with price quotations as often as required, and the rancher in the Chilcotin country of British Columbia can secure the latest quotation on beef before he starts driving his herd to the far distant railway.

These few instances are quoted to show to what extent the government-owned lines may be used in these widely separated sections of Canada.

Canada's Government Buildings

When one realizes that government is the largest industry or business in a country and that accordingly the Dominion Government is the largest concern in Canada, some idea of the extent of the problem of providing and maintaining the accommodation for the transaction of governmental affairs may be formed.

As two of the departments of Government which are most familiar to the public are the Post Office and Customs, or National Revenue, some information on the development of Canada as reflected in the increase in business of these two departments during the last 50 years may be given.

NATIONAL REVENUE

In 1887 there were 28 persons employed in the Customs and 30 in the Excise branches in Ottawa, while outside of Ottawa there were 1,035 in the Customs and 300 in the Excise branches. To-day there are some 620 employed at Ottawa and 4,000 outside of that city. There were only two Customs offices in Manitoba in 1887, one in the Northwest Territories, and three in British Columbia.

In 1887 Customs and Excise duties collected together a total of \$28,700,000, whilst in the fiscal year 1935-36 Customs and Excise accounted for \$128,000,000 besides the Sales Tax bringing in \$116,500,000 and the Income Tax \$82,700,000. During the same period the value of exports has increased tenfold and that of imports six-fold, the staff handling such business being four times as many as that of 1887.

POST OFFICE

As might be expected the work of the Post Office has increased enormously during the last 50 years as the following will show:—

Year	Revenue	Savings Bank Deposits	No. of Post Offices	Money Orders Issued
1886..	\$ 1,825,955	\$17,159,372	7,295	529,458
1936..	32,507,888	22,047,287	12,156	13,123,354

The system for the Special Delivery of letters was inaugurated in 1898, Rural Mail Delivery in 1908, and the Parcel Post Service in 1914.

According to a recent compilation there were 52,731 persons employed by the Government in all parts of the Dominion.

The 71 public buildings under the United Provinces of Canada, at Confederation included 6 post offices and 10 customs houses, the remainder being court houses and gaols, schools, and two observatories. The development of the public building requirements of the Dominion, under the Department of Public Works is indicated by the number of buildings owned and in use from time to time. In 1892 there were 159 buildings; in 1902 there were 285 buildings; in 1912 there were 328 buildings; in 1925 there were 428 buildings; in 1930 there were 593 buildings; and in 1936 there were 612 buildings.

Whilst the greater proportion of business is transacted in the smaller centres where the expenditure involved in the construction and upkeep of a separate building is not warranted, the Post Office business in the medium sized and larger centres is carried on in Government buildings specially designed to house either the Post Office alone or the Post Office in conjunction with work carried out by the Inland Revenue or other Departments and these buildings form a very large proportion of the several types of government buildings erected throughout the Dominion.

The great majority of government buildings are erected and maintained by the Department of Public Works under the Chief Architect's branch. The great variety of buildings designed and the wide range of services therein accommodated may be realized when one mentions not only such departmental buildings as the Confederation, Justice and Connaught Buildings, the East and West Blocks, the National Museum, the National Gallery, the Public Archives, the Central Experimental Farm, and the Dominion Observatory, all of Ottawa; but also such large Dominion buildings as those of Halifax, N.S., Moncton, N.B. (Fig. 13), large Postal Terminals and Customs Buildings at Montreal, buildings for the R.M.C. at Kingston, Ont., the Museum Building at Louisburg, N.S., and the smaller Post Offices as at Notre-Dame de Grace, Que., and Westport, Ont., not to mention Armouries, Barracks and Military Hospitals, Quarantine, Immigration and Detention Hospitals, Fuel Testing and Ore Dressing Laboratories, Research Laboratories for the Agricultural Department, and many other various types of buildings throughout Canada.



FIG. 13.—New Public Building, Moncton, N.B.



FIG. 14.—New Parliament Buildings (Centre Block), Ottawa, Ont.



FIG. 15.—Administration Building, Central Experimental Farm, Ottawa, Ont.



FIG. 16.—Custom and Immigration Building, Douglas, B.C.

In addition to the foregoing work carried out by the Chief Architect's branch of the Department of Public Works, it has been and still is the policy of the Government from time to time, and when there is a particularly heavy building program which would overtax the capacity of the Chief Architect's branch, to employ outside architects in private practice to design and supervise erection of buildings under the supervision of the Chief



FIG. 17.—New Public Building, Winnipeg, Man.

Architect. There are excellent examples of these throughout the land. At Ottawa one finds examples of these in such works as the Parliament Building (with its melodiously be-carilloned Peace Tower, Memorial Chamber, Hall of Fame, and the two great Legislative Chambers of the Commons and the Senate) (Fig. 14), the new Postal Terminal, the National Research Building, and the Administration Block of the Central Experimental Farm

(Fig. 15), whilst further afield the Dominion Government buildings at Hamilton, London, Regina, Vancouver, Winnipeg and Windsor are excellent examples of work carried out by the various practising members of the architectural profession outside. (Figs. 16, 17 and 18).



FIG. 18.—New Customs Building, Montreal, Que.

Historical Architectural Sketch

Ottawa had been chosen by Queen Victoria as the site for the capital of the United Provinces of Canada, and the design submitted by the late Thomas Fuller was selected for the Parliament Buildings which later, at Confederation in 1867, became the Parliament Buildings of the Dominion of Canada.

The construction of public buildings prior to Confederation had been under the Chief Engineer of the United Provinces, John Page, with F. P. Rubidge as Assistant Chief Engineer, and Architect. This continued until 1871, by which time the increasing activities in all branches of construction resulted in the public buildings being placed under a Chief Architect, Thomas Scott being selected for the position.

In 1881 Thomas Fuller (who in the interim had designed and supervised the erection of the State Capitol at Albany, N.Y.) succeeded Thomas Scott. Thomas Fuller was in turn succeeded by David Ewart in 1897 who upon his retirement in 1914 was followed by E. L. Horwood, he being succeeded in 1918 by R. C. Wright, who had previously been Assistant Chief Architect. On the death of R. C. Wright in 1927 Thomas W. Fuller (son of the original Thomas Fuller who had designed the first Parliament Buildings and which were destroyed by fire in 1916) was promoted to become Chief Architect and upon his retirement in 1936 C. D. Sutherland succeeded to the post.

It is interesting to note the trend of architectural taste as evinced from period to period by the buildings erected. There is no doubt that the natural topography of Ottawa with its commanding view calls for a skyline of pointed roofs and towers for its great Legislative and Departmental buildings, the best way of obtaining which was obviously to adopt a Gothic design. Whether, however, the adoption of this style was not rather due to the outcome of the Gothic revival in England so much in vogue at that date, is a moot question. Suffice it to say that it was chosen, and happily so. A Gothic design had been adopted for the Mother of Parliaments in London, but that was of the Perpendicular period, and very different to that employed in the Parliament Buildings in Ottawa. As time passed, a tendency towards a Scotch Baronial type with an admixture of Perpendicular Gothic features can be noticed, as instanced in the National Museum, the Royal Mint and the Connaught Building. Today, as the Dominion Government departmental buildings are spreading out to the west of Parliament Buildings, the Gothic style is fortunately still clung to but of the Northern French Chateau type—perhaps the most appropriate style possible for this part of Canada from all points of view—æsthetic, climatic, sentimental and topographical.

What happened in Ottawa in respect to architectural design during the last 50 years was to a large extent reflected in the designs of buildings throughout the Dominion.

During this period of development advantage has been taken of the opportunities offering to foster the use of building materials of Canadian origin, sandstone from Wallace, N.S., granite from Stanstead, and limestone from Terrebonne, Quebec, Queenston, Ontario, and Tyndall, Manitoba, with marble from Quebec and Manitoba, being examples from among many which might be cited.

Acknowledgments

The Annual Reports of the Department of Public Works, both under the Union Government and since Confederation have naturally been the source to which reference was made for material used in this paper. Acknowledgments is due to the Dominion Bureau of Statistics' most valuable publications on Canada, in particular the "Canada Year Book" for information used therefrom; to "The Canadian Grain Trade," by Duncan Alexander McGibbon, Ma. Ph.D., to which anyone seeking for the knowledge of that subject should refer, and to the "Historical Atlas", by Lawrence J. Burpee.

To C. D. Sutherland, Chief Architect, and F. G. Sims, General Superintendent of Government Telegraphs, are many thanks gratefully expressed for their invaluable assistance in those parts of this paper dealing with the activities of branches of the Department over which they preside most capably.

Names and Dates of Appointments, etc., of the Principal Officials of the Department of Public Works, from 1841 to 1867

UNDER STATUTE 4-5 VIC. CHAP. 38, CORPORATION BOARD OF WORKS

Names	Capacity of office	Date of appointment	
		From	To
Killaly, Hon. H. H.	Chairman		
Daly, Hon. D.	Members	Dec. 21, 1841	Oct. 3, 1844
Harrison, S. B.			
Sullivan, R. B.			
Davidson, J., Esq.	Secretary	Aug. 17, 1841	
Begly, Thomas A.			
Keefer, Samuel			
Rubidge, F. B.			
	Chief Engineer	Aug. 17, 1841	
	Architect and Asst. Chief Engineer	Dec. 15, 1841	
New Board of Works			
Killaly, Hon. H. H.	Chairman		
Daly, Hon. D.	Members	Oct. 4, 1844	June 8, 1846
Draper, Hon. W. H.			
Morris, Hon. W.			
Papineau, Hon. D. B.			

UNDER STATUTE 9 VIC. CHAP. 37, ETC.

Robinson, Hon. W. B.	Chief Commissioner	June 22, 1846	Mar. 10, 1848
Taché, Hon. E. P.	"	Mar. 11, 1848	Nov. 26, 1849
Chabot, Hon. J.	"	Dec. 13, 1849	Mar. 31, 1850
Merritt, Hon. W. H.	"	April 8, 1850	Feb. 11, 1851
Bourret, Hon. J.	"	Feb. 12, 1851	Oct. 27, 1851
Young, Hon. John	"	Oct. 28, 1851	Sept. 22, 1852
Chabot, Hon. J.	"	Sept. 23, 1852	Jan. 26, 1855
Lemieux, Hon. F.	"	Jan. 27, 1855	Nov. 25, 1857
Alleyn, Hon. C.	"	Nov. 26, 1857	Aug. 1, 1858
Holton, Hon. H. L.	"	Aug. 2, 1858	Aug. 6, 1858
Sicotte, Hon. L. V.	"	Aug. 7, 1858	Jan. 10, 1859
Rose, Hon. John	"	Jan. 11, 1859	June 12, 1861
Cauchon, Hon. Joseph	Commissioner	June 13, 1861	May 23, 1862
Tessier, Hon. U. J.	"	May 24, 1862	May 27, 1863
Drummond, Hon. L. T.	"	May 28, 1863	July 23, 1863
Laframboise, Hon. M.	"	July 24, 1863	Mar. 29, 1864
Chapais, J. C.	"	May 30, 1864	June 30, 1867
Casgrain, Hon. Chas. Eus.	Second Comm'r	July 9, 1846	Feb. 29, 1848
Cameron, Hon. M.	Asst. Comm'r	Mar. 11, 1848	Feb. 1, 1850
Wettenhall, James, Esq.	"	Feb. 2, 1850	April 16, 1850
Bourret, Hon. Joseph	"	April 17, 1850	Feb. 11, 1851
Killaly, Hon. H. H.	"	Feb. 12, 1851	May 6, 1859
Keefer, Samuel	Deputy	May 6, 1859	Mar. 7, 1864
Trudeau, Toussaint	"	Mar. 8, 1864	May 29, 1868
Begly, Thomas A.	Secretary	Sept. 25, 1847	Oct. 31, 1858
Trudeau, Toussaint	"	Dec. 13, 1859	Mar. 7, 1864
Braun, Frederick	"	Mar. 8, 1864	July 1, 1867
Page, John	Chief Engineer	Oct. 31, 1853	July 1, 1868

Names and Dates of Appointments, etc., of the Principal Officials of the Department of Public Works from 1867 to Date

UNDER STATUTE 31, VIC., CAP. 12

Names	Capacity of office	Date of appointment	
		From	To
McDougall, Hon. Wm.	Minister.....	July 1, 1867	Dec. 7, 1869
Langevin, Hon. H. L., C.B.	"	Dec. 8, 1869	Nov. 6, 1873
Mackenzie, Hon. Alexander....	"	Nov. 7, 1873	Oct. 16, 1878
Tupper, Sir Charles, C.B., K.C.M.G.	"	Oct. 17, 1878	May 19, 1879
Langevin, Sir Hector, L., C.B., K.C.M.G.	"	May 20, 1879	Aug. 11, 1891
Smith, Hon. Frank.	Acting Minister....	Aug. 14, 1891	Jan. 10, 1892
Ouimet, Hon. J. Alderic.	Minister.....	Jan. 11, 1892	April 30, 1896
Desjardins, Hon. Alphonse.	"	May 1, 1896	July 12, 1896
Tarte, Hon. J. Israel.	"	July 13, 1896	Oct. 21, 1902
Sutherland, Hon. James.	"	Nov. 11, 1902	May 3, 1905
Hyman, Hon. Chas. S.	"	May 22, 1905	Aug. 29, 1907
Pugsley, Hon. Wm.	"	Aug. 30, 1907	Oct. 12, 1911
Monk, Hon. F. D.	"	Oct. 12, 1911	Oct. 22, 1912
Rogers, Hon. Robt.	"	Oct. 29, 1912	Aug. 22, 1917
Ballantyne, Hon. C. C.	"	Oct. 3, 1917	Oct. 13, 1917
Carvell, Hon. F. B.	"	Oct. 13, 1917	Aug. 2, 1919
Sifton, Hon. A. L.	"	Sept. 3, 1919	Dec. 1, 1919
McCurdy, Hon. F. B.	"	July 20, 1920	Dec. 29, 1921
Bostock, Hon. H.	"	Dec. 29, 1921	Feb. 3, 1922
King, Hon. Dr. J. H.	"	Feb. 3, 1922	June 28, 1926
Ryckman, Hon. E. B.	"	July 13, 1926	Sept. 25, 1926
Elliott, Hon. J. C.	"	Sept. 25, 1926	Aug. 7, 1930
Stewart, Hon. H. A.	"	Aug. 7, 1930	Oct. 23, 1935
Cardin, Hon. P. J. A.	"	Oct. 23, 1935	
Trudeau, Toussaint.	Deputy Minister....	May 29, 1868	Oct. 1, 1879
Baillargé, G. F.	"	Oct. 4, 1879	Dec. 31, 1890
Gobeil, A., I.S.O.	"	Jan. 1, 1891	June 2, 1908
Hunter, James B.	"	July 1, 1908	
Hunter, James B.	Asst. Deputy Min'er	Jan. 1, 1908	July 1, 1908
St. Laurent, A.	"	July 1, 1908	Feb. 1, 1922
Desrochers, R. C.	"	April 1, 1923	Oct. 9, 1929
O'Brien, S. E.	"	Nov. 1, 1929	Sept. 1, 1934
Desjardins, N.	"	July 16, 1935	
Braun, Frederick.	Secretary	July 1, 1867	Sept. 30, 1879
Chapleau, S.	"	Oct. 1, 1879	Nov. 4, 1880
Ennis, F. H.	"	Nov. 5, 1880	Jan. 13, 1885
Gobeil, A.	"	Jan. 23, 1885	Dec. 31, 1890
Roy, E. F. E.	"	Jan. 1, 1891	Dec. 31, 1900
Gélinas, Fred.	"	June 8, 1901	July 2, 1908
Tessier, Napoléon.	"	Aug. 11, 1908	June 2, 1910
Desrochers, R. C.	"	July 1, 1910	April 1, 1923
Colman, L. H.	"	Oct. 1, 1923	April 26, 1924
O'Brien, S. E.	"	July 1, 1924	Nov. 1, 1929
Desjardins, N.	"	Nov. 1, 1929	July 16, 1935
Somerville, J. M.	"	Dec. 1, 1935	
McPherson, D. A.	Asst. Secretary....	Jan. 18, 1891	April 11, 1893
Desrochers, R. C.	"	Jan. 8, 1896	June 30, 1910
Dillon, R. W.	"	Dec. 19, 1910	Mar. 23, 1911
Colman, L. H.	"	May 23, 1911	Oct. 1, 1923
Desjardins, N.	"	Nov. 1, 1923	Nov. 1, 1929
Somerville, J. M.	"	Feb. 1, 1930	Dec. 1, 1935

**Names and Dates of Appointments, etc., of the Principal Officials of the
Department of Public Works from 1867 to Date—Concluded**

Names	Capacity of office	Date of appointment	
		From	To
Drouin, J. A.....	“.....	April 1, 1936	.....
Page, John.....	Chief Engineer.....	July 1, 1868	Oct. 1, 1879
Perley, Henry F.....	“.....	Nov. 25, 1880	Oct. 10, 1891
Coste, Louis.....	“.....	July 26, 1892	Mar. 3, 1899
Lafleur, E. D.....	“.....	Dec. 1, 1904	Dec. 14, 1922
St. Laurent, A.....	“.....	Feb. 1, 1922	Mar. 6, 1923
Cameron, K. M.....	“.....	April 1, 1923	.....
St. Laurent, A.....	Asst. Chief Engineer	Nov. 1, 1905	Aug. 2, 1908
Brown, G.....	“.....	Sept. 11, 1909	Mar. 1910
Dufresne, A. R.....	“.....	May 13, 1910	Sept. 1, 1918
Cameron, K. M.....	“.....	Nov. 1, 1918	April 1, 1923
Corriveau, R. DeB.....	“.....	Nov. 1, 1923	.....
Scott, Thos. L.....	Chief Architect.....	May 26, 1871	Oct. 30, 1881
Fuller, Thos.....	“.....	Oct. 31, 1881	June 30, 1897
Ewart, David.....	“.....	Nov. 2, 1897	Sept. 30, 1914
Horwood, E. L.....	“.....	Oct. 1, 1914	Mar. 31, 1918
Wright, R. C.....	“.....	May 1, 1918	Jan. 19, 1927
Fuller, T. W.....	“.....	Dec. 1, 1927	Nov. 3, 1936
Sutherland, C. D.....	“.....	Nov. 3, 1936	.....
Wright, R. C.....	Asst. Chief Architect	Dec. 1, 1906	June 1, 1914
Fuller, T. W.....	“.....	May 1, 1918	Dec. 1, 1927
Hutchison, G. N.....	“.....	April 1, 1928	April 22, 1936
Sutherland, C. D.....	“.....	May 1, 1936	Nov. 3, 1936
Brault, J. C. G.....	“.....	Nov. 3, 1936	.....
Gisborne, F. N.....	Gen. Supt. Tele- graphs.....	May 1, 1879	Aug. 29, 1892
Keeley, D. H. (Acting).....	“.....	Aug. 30, 1892	July 1, 1894
Keeley, D. H. (Appointed).....	“.....	July 1, 1894	July 1, 1923
Gobeil, J. E.....	“.....	July 1, 1923	Aug. 7, 1930
Sims, F. G.....	“.....	Sept. 1, 1930
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